UNITED STATES COMMISSION OF FISH AND FISHERIES.

PART V.

REPORT

OF

THE COMMISSIONER

FOR

1877.

A.—INQUIRY INTO THE DECREASE OF FOOD-FISHES.
B.—THE PROPAGATION OF FOOD-FISHES IN THE WATERS OF THE UNITED STATES.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1879.

LETTER

FROM THE

COMMISSIONER OF FISH AND FISHERIES,

TRANSMITTING

His report for the year 1876–'77.

MARCH 27, 1878.—Ordered to lie on the table and be printed.

UNITED STATES COMMISSION, FISH AND FISHERIES,
Washington, March 18, 1878.

GENTLEMEN: In compliance with the order of Congress I have the honor to transmit herewith my report for the year 1876–'77, as United States Commissioner of Fish and Fisheries, embracing, first, the result of inquiries into the condition of the fisheries of the sea-coast and lakes of the United States; and, second, the history of the measures taken for the introduction of useful food-fishes into its waters.

Very respectfully, your obedient servant,

SPENCER F. BAIRD,
Commissioner.

Hon. WM. A. WHEELER,
President United States Senate, and
Hon. S. J. RANDALL,
Speaker of the House of Representatives.

CONTENTS.

I.—REPORT OF THE COMMISSIONER.

A.—GENERAL CONSIDERATIONS.

B.—INQUIRIES INTO THE HISTORY AND STATISTICS OF FOOD-FISHES.

C.—THE HALIFAX CONVENTION.

D.—FISHERY STATISTICS.

E.—NOTICE OF ARTICLES RELATIVE TO THE SEA-FISHERIES PUBLISHED IN THE APPENDIX.

F.—THE PROPAGATION OF FOOD-FISHES.

II.—APPENDIX TO REPORT OF COMMISSIONER.

APPENDIX A.—THE SEA-FISHERIES.

APPENDIX B.—THE PROPAGATION OF FOOD-FISHES.

APPENDIX C.—MISCELLANEOUS.

REPORT OF THE COMMISSIONER.

A—GENERAL CONSIDERATIONS.

1—INTRODUCTORY REMARKS.

In presenting an account of the operations of the United States Fish Commission in 1877, it may be well to premise that while representing the sixth year of its work, it constitutes the fifth report of the series, that of two years having once been combined in the same report (1873–'74 and 1874–'75) for reasons referred to in the volume.

As heretofore, it has been found impossible to confine the record to the calendar—or even strictly to the fiscal year, it being considered desirable to give a full, connected, and complete account of the operations in each branch of fish propagation from the beginning to the end. Thus, while the work relating to the eastern Salmon extends from May to the following February or March, that connected with the Shad is begun in March or April, and generally extends only into June or July.

In volume IV of the series of reports will be found a running history of operations up to the beginning of 1877. The present volume takes up the thread and carries it forward in part into the year 1878.

It has already been explained in previous reports that while the labors of the Commission, as originally assigned by Congress in 1871, had reference more particularly to an inquiry into the condition of the sea-fisheries and the influences affecting them, they were largely increased and extended in 1872 by the order to include the general subject of introducing useful food-fishes into appropriate waters of the United States, or restoring them in already depleted rivers. While the first branch involves a somewhat active research during the summer season, when it is most convenient and practicable, the second requires constant activity throughout the year, both in the way of field-work and of extended official correspondence.

The increased appropriations by Congress have greatly increased the labor and responsibility, without any increase of staff, and with the exercise of the most rigid economy it is hoped that the results are becoming greater and greater in proportion to the expenditures.

It is gratifying to observe the constantly-increasing interest in the labors of the Commission, shown by the extensive correspondence induced at home and abroad and by the hearty co-operation of the State Fish Commissions in the common object, both of investigation into the condition of the fisheries and in their improvement.

The same system of subdivision of duty on the part of the *personnel* of the Commission has been continued as in previous years. The general subject of the propagation of food-fishes has been mainly in charge of Mr. James W. Milner, the Assistant Commissioner, while that of inquiry into the statistics of the fisheries has been prosecuted with the especial assistance of Mr. G. Brown Goode, curator of the National Museum. This gentleman, in addition to the statistical inquiry, has also had charge of the field-work connected with the vertebrates. Prof. A. E. Verrill, with his staff, has supervised the explorations and investigations connected with the marine invertebrates, and Professor Farlow those relative to the useful sea-plants. The special assistants in these various divisions will be hereafter mentioned.

B—INQUIRY INTO THE HISTORY AND STATISTICS OF THE FOOD-FISHES.

2.—OPERATIONS DURING THE SUMMER OF 1877.

It has been my pleasant duty, in all the preceding volumes of this series of reports, to acknowledge the hearty responses of the various departments of the government to that portion of the law organizing the United States Fish Commission which directs them to render to it such aid as lies in their power, all whose assistance has been invoked acting upon the spirit of the law, and without restriction to its mere letter. The Treasury, the War, and the Interior Departments all require especial mention in this connection. The co-operation of the Navy Department has been of the greatest importance by lending certain vessels not required at the time for the regular purposes of the department. These consisted of a small steam-launch in 1871, and the steam-tug Blue Light, a vessel of about 100 tons, in 1873, 1874, and 1875. No call was made upon the department in 1876, as no field parties were out during the summer of that year, my presence and that of my assistants being required in connection with the exhibits of the Smithsonian Institution, the National Museum, and the United States Fish Commission at the International Exhibition in Philadelphia. For the season of 1877, however, the assistance of Secretary Thompson, of the Navy, was invoked, and a larger vessel than the Blue Light was detailed by him for duty with the Commission. This was the steam-tug Speedwell, an iron propeller of 306 tons, with a powerful engine, and well adapted to her work. She was put in thorough order at the Portsmouth navy-yard, and reported for duty at Salem on the 31st of July. She had previously left Portsmouth, on the 20th of July, for New London, for the purpose of taking on board the stores of the Blue Light, the vessel previously employed, and of having the hoisting-engine of the latter transferred to her own deck. She also stopped at Wood's Holl, July 26, to take on board the other equipments and articles necessary for her service. The steamer was placed by the Secretary in charge of Lieutenant-Commander

A. G. Kellogg, with Dr. T. H. Streets, surgeon, Mr. A. V. Zane as chief engineer, and Mr. J. A. Smith, who had had much experience in scientific work on the vessels of the Coast Survey, as first mate. A detail of the necessary petty officers and seamen completed the *personnel* of the vessel.

The usual corps of specialists in science took part in the operations of the Commission during the summer. Prof. A. E. Verrill, of Yale, had charge of the marine invertebrates, assisted by E. B. Wilson.

Mr. G. Brown Goode, of the National Museum, assisted by Dr. T. H. Bean, superintended all matters connected with the fisheries. The laboratory and the dredging and trawling apparatus were in charge of Capt. H. C. Chester.

I reached Salem on the 3d of July, and was joined a few days after by the remainder of the force, the Speedwell not arriving, as stated, until July 31, before which date, however, a considerable amount of preliminary work was accomplished, especially in the collecting of statistics of the fisheries at Salem.

The Commission had a large number of visitors during the summer, many of them engaged in special research, for which ample material was furnished them by the collections of the Commission.

The usual routine of exploration was followed at the Salem Station, consisting of frequent trips of the steamer in various directions, during which the dredge and trawl were brought into requisition, and specimens secured of various marine animals and plants. Soundings were made, and their depth and character recorded, and an accompanying series of observations made upon the temperature of the ocean at various distances below the surface.

STATION AT HALIFAX.

On the 14th of August, for reasons to be referred to hereafter, I proceeded to Halifax, Nova Scotia, there to form a second station for the summer, arriving on the 17th. (I had previously dispatched Mr. Goode to that city to select suitable accommodations for the steamer and laboratory.) The steamer left Salem a few days later, and proceeded directly across, arriving on the 22d, and bringing with her the principal portion of the scientific corps. The occasion of the trip from Salem to Halifax was embraced to make numerous deep-sea investigations of the temperature of the water, the depth, and the animal life, resulting in the discovery of quite a number of new forms. A suitable berth and buildings for the service of the steamer having been engaged from Mr. Belcher, on Bennett's wharf, at Halifax, the sea work was continued with very little intermission until the 13th of October, when the vessel returned to Salem to complete some inquiries that had been commenced during the summer, and closing operations on the 24th of October, she proceeded to Portsmouth and went out of commission, having thus been in service since the 20th of July, or for rather more than three months.

At Halifax, as at Salem, there were numerous visitors to the laboratory and the vessel, and the aggregate of the work accomplished at the two stations was much greater than that of any previous season.

The work at Salem was greatly facilitated by help rendered by the officers and members of the Peabody Academy of Science and of the Essex Institute; the rooms, libraries, and collections of these establishments being freely at the service of the Commission, as also the special knowledge of the scientific members. Among these may be especially mentioned, Dr. A. S. Packard, jr., Mr. Caleb Cook, Mr. J. H. Emerton, Mr. A. L. Kingsley, Mr. John Robinson, and Dr. Henry M. Wheatland. A similar service was rendered at Halifax by the members of the Nova Scotia Institute of Science, among them Dr. Honeyman, curator of the museum, Mr. J. Matthew Jones, Mr. Morrow, and Mr. William Gossip. To Prof. H. Y. Hind, of Windsor, Nova Scotia, the acknowledgements of the Commission are specially due for furnishing for its use a number of the newly-devised deep-sea thermometers of Messrs Negretti & Zambra, and for aid in other directions. To the authorities, both of the Dominion and of the Province of Nova Scotia, and especially to the Hon. J. Burpee, minister of customs, the Commission is also indebted for many valuable courtesies, and especially in having the steamer and her apparatus placed on the same footing with Her Majesty's vessels of war, by means of which all necessary supplies were obtainable free of duty. Under this provision, all the alcohol required for the preservation of specimens was secured at a very moderate price, and all supplies and apparatus needed from the United States were imported duty free. Hon. W. F. Whitcher, Commissioner of Fisheries, Canada, also issued a permit authorizing Mr. Milner to make collection of specimens of fish for the United States Fish Commission in parts of Canada where the use of the seine is at present forbidden.

GENERAL RESULTS OF THE SEA-WORK OF 1877.

The field-work prosecuted by the United State Fish Commission during 1877, as usual, produced the usual variety of results, both theoretical and practical. The information obtained is believed to be of much value, although of greatest importance in connection with corresponding observations of other years, the digests of which are in preparation, and will be published as a series of final reports.

Perhaps the most important single fact ascertained by the Commission was that of the occurrence, off the whole coast of New England, of a large flounder (*Glytocephalus cynoglossus*), known in Europe as the Pole or Craig, and in the most extraordinary abundance, and, strange to say, entirely unknown to the fishermen. It proved to be most excellent as food, and, indeed, quite similar in gastronomic excellence to the Turbot, possessing, like that fish, a large amount of the same gelatinous fat along the fins, which gives the Turbot its peculiar excellence.

The Pole-flounder is rare on the coast of Middle Europe, but perhaps more abundant in the Scandinavian seas; but nowhere do they appear in such numbers as on the American coast. Indeed, we may almost assume that they have only straggled in small numbers from the new world to the old. It was found no nearer to the coast than from five to ten miles, in waters not less than about forty to fifty fathoms in depth, consequently belonging to the colder strata. Here, however, it was taken by the trawl in enormous quantities; so great, indeed, that a fifteen to twenty minutes' drag would sometimes furnish as many as 500 pounds of the fish.

The reason that this fish has not been known hitherto is due to the fact that the beam-trawl, the only apparatus by which it can be taken, is not in use on the American coast, as it is in Europe, for the supply of sea-fish to the markets. The mouth of the Pole is so diminutive, that a hook sufficiently minute to be swallowed would not sustain the weight of the fish, which, on the other hand, is unable to swallow an ordinary cod or haddock bait. There is every reason to believe that in time this fish will become an important article of food in the Eastern markets; but for taking it the beam-trawl must be employed.

Many facts of great scientific interest were also ascertained in regard to the distribution of the marine fishes, and the occurrence ascertained near or on our shores of species previously undescribed, or known only from more northern waters. We have every reason to expect that in time almost all the characteristic fish of the cold waters of Greenland and Scandinavia will be taken within two or three hundred miles of the American coast.

Copious and desirable information was gathered in respect to the occurrence and geographical disitribution of marine invertebrates and plants, some of them undescribed species, and others very far out of their previously-known range.

As already explained, the various questions relating to the history, condition, habits, and peculiarities of our more notable food-fishes have had much light thrown upon them by the labors of the summer. As in previous years, specimens were gathered and preserved in large numbers, not simply for the purpose of enriching the stores of the National Museum, but also for supplying very important educational cabinets to colleges, academies, and high schools throughout the country. There are no subjects of greater interest at the present day than those connected with the history and development of many forms of marine animals, life in the sea being vastly more varied than that of the corresponding orders on land; where, indeed, some are not represented at all. Material of this kind, however, is almost inaccessible to our best apppointed museums, as it is not often that the services of a steamer, with a complete equipment of apparatus for research, can be commanded. On that account the Commission has considered it a duty to utilize the present opportunities, which cannot be expected to continue indefinitely, in obtaining enough material to meet all present and expected needs.

As in previous years, the marine invertebrates have been placed in the hands of Professor Verrill to be classified, and the duplicates arranged in sets for future distribution, and it is hoped that all proper wants can in this way be met. Of course, these collections must be carefully husbanded and given only to permanent institutions, able and willing to furnish the necessary alcohol and jars for their preservation. It is also expected that, by the exchange of some of these series with museums abroad, the National Museum may derive important additions to its collections of objects needed for research in America.

As heretofore, the fishes collected have been placed for identification in the hands of Mr. Goode, curator of the National Museum, aided by Dr. T. H. Bean, and with the co-operation of Prof. Theodore Gill.

C—THE HALIFAX CONVENTION.

4.—THE TREATY OF WASHINGTON.

Among the various subjects intrusted to the High Joint Commission held at Washington which prepared what is known as the Treaty of Washington (concluded and signed on the 8th of May, 1871), was the settlement of the difficulties in regard to the fisheries off the coast of British North America, which have been for many years a source of irritation between the two countries. The assumed rights of Great Britain in the waters adjacent to her American territory have always been maintained with great firmness, although with varying degrees of stringency; the crossing by American fishing vessels of the maritime territorial line for any other purpose than shelter being at intervals rigorously prohibited. At one time the seaward limit of jurisdiction claimed extended almost indefinitely off the coast; but ultimately the three-mile line was accepted, but made to include the distance between the headlands of all bays, the Bay of Fundy among the number; and quite a number of vessels were confiscated for violating the law by fishing within the prohibited line. It was, however, established in an English court that the claim to the Bay of Funday was untenable; and although no test case has since then arisen in regard to narrower bays, the United States maintain that the restriction can only apply to bays or portions thereof which are less than six miles from side to side.

During the period of the Reciprocity Treaty, American vessels had free access to all parts of the British waters of North America; but when this was brought to a conclusion the old difficulties were renewed, and although a system of licensing was adopted, by which, on payment of a certain sum per ton (at first fifty cents and afterward increased), the right of fishing was granted, many vessels refused to avail themselves of this chance, and so much ill-feeling was produced that it was concluded to add the fishery question in general to the other subjects to be determined by the Treaty of Washington of 1871.

By the Treaty of 1818 certain portions of the British shores were opened

perpetually to American fishermen, especially the south coast of Newfoundland from the Rameau Islands to Cape Ray, and the west coast from Cape Ray to the Quirpon Islands, the shores of the Magdalen Islands, and the southern coast of Labrador from Mount Joly to and through the Straits of Belle Isle, and thence northward indefinitely along the coast. By the Washington Treaty of 1871* the other shores

---

* ARTICLE XVIII.—It is agreed by the High Contracting Parties that in addition to the liberty secured to the United States fishermen by the Convention between Great Britain and the United States, signed at London on the 20th day of October, 1818, of taking, curing, and drying fish on certain coasts of the British North American Colonies therein defined, the inhabitants of the United States shall have, in common with the subjects of Her Britannic Majesty, the liberty, for the term of years mentioned in Article XXXIII of this Treaty, to take fish of every kind, except shell-fish, on the sea-coasts and shores, and in the bays, harbors, and creeks of the Provinces of Quebec, Nova Scotia, and New Brunswick, and the Colony of Prince Edward's Island, and of the several islands thereunto adjacent, without being restricted to any distance from the shore, with permission to land upon the said coasts and shores and islands, and also upon the Magdalen Islands, for the purpose of drying their nets and curing their fish; provided, that in so doing they do not interfere with the rights of private property or with British fishermen in the peaceable use of any part of the said coasts in their occupancy for the same purpose.

It is understood that the above-mentioned liberty applies solely to the sea-fishery, and that the salmon and shad fisheries and all other fisheries in rivers and the mouths of rivers, are hereby reserved exclusively for British fishermen.

ARTICLE XIX.—It is agreed by the High Contracting Parties that British subjects shall have, in common with the citizens of the United States, the liberty, for the term of years mentioned in Article XXXIII of this Treaty, to take fish of every kind, except shell-fish, on the eastern sea-coasts and shores of the United States north of the thirty-ninth parallel of north latitude, and on the shores of the several islands thereunto adjacent, and in the bays, harbors, and creeks of the said sea-coasts and shores of the United States and of the said islands, without being restricted to any distance from the shore, with permission to land upon the said coasts of the United States and of the islands aforesaid for the purpose of drying their nets and curing their fish; provided, that in so doing they do not interfere with the rights of private property or with the fishermen of the United States in the peaceable use of any part of the said coasts in their occupancy for the same purpose.

It is understood that the above-mentioned liberty applies solely to the sea-fishery, and that salmon and shad fisheries, and all other fisheries in rivers and mouths of rivers, are hereby reserved exclusively for fishermen of the United States.

ARTICLE XX.—It is agreed that the places designated by the Commissioners appointed under the 1st article of the Treaty between Great Britain and the United States, concluded at Washington on the 5th of June, 1854, upon the coasts of Her Britannic Majesty's dominions and the United States, as places reserved from the common right of fishing under that Treaty, shall be regarded as in like manner reserved from the common right of fishing under the preceding articles. In case any question should arise between the Governments of the United States and of Her Britannic Majesty as to the common right of fishing in places not thus designated as reserved, it is agreed that a commission shall be appointed to designate such places, and shall be constituted in the same manner, and have the same powers, duties, and authority as the commission appointed under the said 1st article of the Treaty of the 5th of June, 1854.

ARTICLE XXI.—It is agreed that, for the term of years mentioned in Article XXXIII of this Treaty, fish-oil and fish of all kinds (except fish of the inland lakes and of the

of the Dominion of Canada and of Newfoundland were included in the same privilege, the United States conceding a similar right of fishing from the latitude of 39°, or the southernmost point of New Jersey to the Bay of Fundy. The right of entrance of fish of either country to the ports of the other, free of duty, was also granted.

The river fisheries, especially of shad and salmon, as also those of shell-fish, were, however, expressly excepted from the provisions of the treaty, which was to continue for twelve years from the date of its ratification.

It having been asserted that the privileges granted to the United States by Great Britain were greater than those conceded by the former, the Washington treaty provided that commissioners should be appointed to determine this question, and that any sum of money awarded by the said commissioners should be paid by the United States in a gross

---

rivers falling into them, and except fish preserved in oil), being the produce of the fisheries of the United States, or of the Dominion of Canada, or of Prince Edward's Island, shall be admitted into each country, respectively, free of duty.

ARTICLE XXII.—Inasmuch as it is asserted by the Government of Her Britannic Majesty that the privileges accorded to the citizens of the United States under Article XVIII of this Treaty are of greater value than those accorded by Articles XIX and XXI of this Treaty to the subjects of Her Britannic Majesty, and this assertion is not admitted by the Government of the United States, it is further agreed that Commissioners shall be appointed to determine, having regard to the privileges accorded by the United States to the subjects of Her Britannic Majesty, as stated in Articles XIX and XXI of this Treaty, the amount of any compensation which, in their opinion, ought to be paid by the Government of the United States to the Government of Her Britannic Majesty in return for the privileges accorded to the citizens of the United States under Article XVIII of this Treaty; and that any sum of money which the said Commissioners may so award shall be paid by the United States Government, in a gross sum, within twelve months after such award shall have been given.

ARTICLE XXIII.—The Commissioners referred to in the preceding article shall be appointed in the following manner, that is to say: One Commissioner shall be named by Her Britannic Majesty, one by the President of the United States, and a third by Her Britannic Majesty and the President of the United States conjointly; and in case the third Commissioner shall not have been so named within a period of three months from the date when this article shall take effect, then the third Commissioner shall be named by the representative at London of His Majesty the Emperor of Austria and King of Hungary. In case of the death, absence, or incapacity of any Commissioner, or in the event of any Commissioner omitting or ceasing to act, the vacancy shall be filled in the manner hereinbefore provided for making the original appointment, the period of three months in case of such substitution being calculated from the date of the happening of the vacancy.

The Commissioners so named shall meet in the city of Halifax, in the Province of Nova Scotia, at the earliest convenient period after they have been respectively named, and shall, before proceeding to any business, make and subscribe a solemn declaration that they will impartially and carefully examine and decide the matters referred to them to the best of their judgment, and according to justice and equity; and such declaration shall be entered on the record of their proceedings.

Each of the High Contracting Parties shall also name one person to attend the Commission as its agent, to represent it generally in all matters connected with the Commission.

amount within twelve months after the award should have been given. The commissioners were to be three: one appointed by the President of the United States, one by Her Britannic Majesty, and the third by the two conjointly; and in case the third commissioner should not have been named within three months of the appointment of the others, he was to be designated by the Austrian minister in London.

The court so constituted was also to meet at Halifax at the earliest convenient period. An agent was to be appointed respectively by Great Britain and by the United States for the purpose of conducting the proceedings.

The treaty having been ratified by all the parties interested in 1873, its provisions commenced in that year, but it was not until 1877 that the convention referred to met at Halifax.

Governor Clifford, of New Bedford, Mass., was appointed the American commissioner by the President of the United States; but his death prevented the organization of the convention, and it was not until some time afterward that Mr. Ensign H. Kellogg, of Pittsfield, Mass., was chosen and arrangements initiated for holding the convention. Sir Alexander T. Galt, of Montreal, was appointed commissioner by Her Britannic Majesty, and the third commissioner, who was also president of the court, was Mr. Maurice Delfosse, the Belgian minister at Washington. The American agent was Hon. Dwight Foster, a prominent lawyer of Boston; the British, Mr. Francis Clay Ford, some years ago secretary of the British Legation at Washington, but at present Her Britannic Majesty's minister at Darmstadt.

5.—THE MEETING AT HALIFAX.

After some time spent in collecting evidence and in preparing for the case, the meeting finally opened at Halifax, on the 15th of June, 1877, and the period of six months, within which the treaty required that the operations of the court should be concluded, was appropriately parcelled out. The proceedings commenced with the adoption of rules of procedure, followed by the presentation of the British case, in which a claim was made for $12,000,000 in behalf of the Dominion of Canada and of $2,400,000 for Newfoundland, after which an adjournment of six weeks was had to permit the American agent to make up his reply.

When the convention again met six weeks were allowed for the presentation of testimony on the British side, followed by six weeks for that of the American. A week was then given for rebuttal, after which the American agent and counsel summed up for their side of the question, and were followed, after a suitable interval, by their opponents.

The decision was rendered on the 23d of November, closing the operations within the six months limited, which would have expired on the 15th of December.

The American agent, Hon. Dwight Foster, had as associate Mr. Rich-

ard Henry Dana, jr., of Boston, the well-known author of "Two Years Before the Mast," and a specialist in matters connected with maritime law, and Mr. William H. Trescott, who had been Assistant Secretary of State under Buchanan, and was well versed in all matters of diplomatic routine.

The British agent was assisted by leading lawyers from all the British Provinces of North America: Mr. Joseph Doutre, of Montreal, representing Quebec and Ontario; Mr. Louis H. Davies, of Charlottetown, Prince Edward's Island; Mr. W. V. Whiteway, of St. Johns, Newfoundland; Mr. R. L. Wetherbe, of Halifax, Nova Scotia; and John S. R. Thompson, of St. John, New Brunswick, for those provinces respectively.

Many hundreds of witnesses were produced on both sides, their testimony, as might be imagined, being very opposite as to the value of the privileges conceded by the two contracting parties. An immense mass of evidence was taken and printed day by day, embodying a great deal of valuable information respecting all subjects connected with the fish and fisheries of the northern seas. After a full consideration of all the evidence presented to the court and elucidated by the arguments of the counsel respectively, an award was made by Mr. Alexander Galt and Mr. Delfosse of $5,500,000, as representing the excess in value of the privileges conceded to the United States for the period of twelve years from 1873. Mr. Kellogg, however, dissented from this, and gave it as his opinion that the United States received less than she gave, and entered a protest against the payment of the awards by the suggestion that this could only be binding by a unanimous decision of the commissioners, the words of the treaty being "that any sum of money which the said *commissioners* may so award shall be paid by the United States in a gross sum within twelve months after such an award shall have been given," and without specifying that an award might be made by a majority of the commissioners. After some correspondence, however, of the State Department with the British Government on the points at issue, Congress made the necessary appropriation, and the full amount awarded was paid to Great Britain before the expiration of the year from the date of the award.

6.—RELATIONS OF THE UNITED STATES FISH-COMMISSION TO THE HALIFAX CONVENTION.

Having been invited by Mr. Evarts, the Secretary of State, in June, 1877, to assist the American counsel in the collection and preparation of data to be used before the Halifax Commission, I was enabled to find in the material gathered during the inquiry into the condition of the food-fishes for the last six years, very many important facts bearing upon the case.

One special point to be determined, was the value of the inshore sea-fisheries of the United States from the Bay of Fundy to Delaware

Bay.* The absence of any system on our part for collecting facts on this subject was never more fully appreciated than when it was needed to protect the United States against an unjust award. Everything possible, however, was done to supplement the deficiency. Lists were obtained from the Post-Office Department of all post-offices along the Atlantic coast situated within three miles of the shore, and a circular was prepared and mailed to the postmasters, asking for the names and addresses of all persons within their knowledge, who were interested in fishing or the fisheries, whether as principals or accessories. A circular was then prepared specifying the nature of the information desired, the main points being the kinds of fish taken, the seasons, the mode of capture, and the proportion of the whole, caught within three miles of the land.

Special information was asked in addition as to the character and quantity of the fish taken off the shores of the British Provinces, especially within the three-mile limit.

Competent agents were also dispatched to visit the principal fishing stations in Vineyard Sound, Buzzard's Bay, Long Island Sound, &c., and the services of a number of the leading fish-dealers in New York were secured. A number of persons, also, able to give particular information were either visited personally or invited to attend at some suitable point for further conference.

The result of these labors was that by the time the information was needed it became possible to present to the commission, through the American counsel, quite a satisfactory series of tables which answered an excellent purpose.

After spending the necessary time in Boston, Salem, &c., in gathering a portion of this information, I proceeded to Halifax, as already explained, under the division of "The Halifax Station," arriving, as there mentioned, on the 17th of August.

I immediately placed myself in communication with Judge Foster, the American counsel of the commission, and remained until the 22d of

* The value of the sea-fisheries of the United States, east of Cape May, was ascertained to be $13,030,821, against $8,418,663.25, the value of the Canadian sea-fisheries, as shown by the official reports of 1876.

The length of the Dominion coast-line in miles is 2,865, the yield of fish to mile of coast-line amounts to 160,934 pounds, valued at $2,938.10.

The United States has 1,112 miles of coast-line, east of Cape May, the yield of fish to the mile averaging 287,392 pounds, valued at $3,655; this is for the inshore fisheries alone, while the estimate for the Dominion of Canada includes all the sea-fisheries. The total yield of the in and off shore fisheries of the United States, for the region between Cape May and the Bay of Fundy, amounted for each mile to 940,510 pounds, valued at $11,718.

The table, which was prepared to illustrate the marine-fisheries of Southern Massachusetts and Rhode Island, exhibited still more astounding totals. Within a stretch of coast-line 250 miles in length, the weir-fisheries alone yielded an average return of 137,097 pounds to the mile, with a mean value of $4,642, while to each man employed in the fishery the yield amounted to 78,610 pounds, with a mean value of $2,661.

October. A number of hours was spent each day in the court room listening to the testimony and rendering such assistance to the American commissioner as circumstances made necessary. I was myself called as a witness, several days being spent under direct or cross-examination. The progress of the investigations of the commission involved not merely points relating to the violation of the fishery laws and the injury done to fisheries of the two countries respectively, but also all imaginable conditions attendant upon their prosecution, and especially certain alleged improper modes of pursuit and capture. The use of the trawl or long line by the Americans on the British shores had been made a source of grave complaint and constituted one of the charges in the indictment against the United States, as also the employment of the purse-seine for the capture of mackerel. The question, therefore, of the actual influence of these engines on the fisheries had to be considered very minutely, and a great deal of argument was expended on opposite sides in the discussion.

Many interesting points as to the habits of the food-fishes, their migrations generally, their mode of spawning, period of development, &c., were also elicited; and although the evidence given was very contradictory, it has been possible in sifting it to get out a large number of facts of great biological and practical importance. Much noteworthy information in these respects was obtained from Capt. Nathaniel Atwood, of Provincetown, and Mr. Simeon F. Cheney, of Grand Menan; these two gentlemen having for a long period of years carefully noted and recorded many facts previously unknown to naturalists. The migrations of the mackerel were made the subject of special study, and a large map was prepared and exhibited in the council chamber in which the meeting was held, showing the periodical movements of the mackerel schools, the location of the spawning-grounds, and the dates of the season of reproduction. Most of the data for this were furnished by Capt. R. H. Hulbert.

The data obtained at the Halifax Convention and otherwise will be used hereafter in preparing a systematic and methodical account of the sea-fisheries of Eastern North America, and will include, first, the natural history of the fish themselves; second, an account of all the methods of pursuit and capture; third, the mode of preparation for market and for shipment; and fourth, the general statistics of the whole subject.

As already intimated, the American side labored under a serious disadvantage for want of methodical and regular statistics of the fisheries of the United States. The case was quite different, however, with the other party. The authorities of Canada had for many years kept and published annually an extremely exhaustive account of everything taken in their fisheries, giving the number of each kind of fish taken and preserved in each province, county, and district, as also the exportations to foreign countries, including the United States.* The Minister of

* The minuteness with which this method is carried out is illustrated in report of Mr. Whitcher, commissioner of fisheries for the Dominion of Canada, which, for the

Marine and Fisheries, Mr. A. J. Smith, was present much of the time, while Mr. William F. Whitcher, superintendent of fisheries of Canada, with one or more assistants, was constantly on hand to render any explanation or give any further information in his power. It is greatly to be hoped that, whether with reference to future conventions of this kind or not, the necessary steps will be taken by the United States to secure data corresponding to those taken regularly and systematically in Canada. While it may only be practicable for the States to secure information in regard to the detailed catch in rivers, ponds, and other inland waters, there certainly need be no difficulty on the part of the United States in obtaining the facts necessary to a full understanding of the coast fisheries. All vessels above a certain size must be licensed for the fisheries, in return for which they obtain certain privileges in the way of free salt. It will be entirely proper as a return, to require information as to the nature and magnitude of the catch of each vessel, the precise field of operations, and especially as to the quantity of fish taken within three miles of the shore of either the United States or the British provinces.

Having referred to the information furnished by Captain Atwood and Mr. Cheney, it is proper to state that very important statistics in regard to the sale of fresh fish in the New York market were obtained through the instrumentality of Mr. E. G. Blackford, the well-known fish-dealer of Fulton Market. Mr. Vinal N. Edwards, of Wood's Holl, an employé of the United States Fish Commission, secured a great amount of information by personally visiting the fishing-grounds of Vineyard Sound and Buzzard's Bay.

The labor of compiling and digesting the statistics furnished to the Commission, and obtained from various sources, was in charge of Mr. G. Brown Goode, whose faithful and comprehensive services in this respect entitle him to the heartiest acknowledgments

D.—STATISTICS OF THE SEA-FISHERIES.

The necessity of having at hand more accurate statistics of the great fisheries of the United States, both sea-coast and inland, so urgently

year ending December 31, 1877, contains a series of very exhaustive tables showing in detail the results of the fisheries in every province of the Dominion. Too much cannot be said in commendation of the very thorough method in which the Canadian Government regulates and protects its fisheries. Accurate statistical information is the one essential foundation upon which protective legislation must rest. This is obtained by a system, not very cumbersome and not very expensive, which, under the direction of Mr. Whitcher, seems to be very efficient. The number of men employed in the staff of fishery officers in 1877 was 601, 595 of whom are observers and wardens, with salaries ranging from $20 to $500; the others, officers of steamers or inspection officers, with salaries of $800 to $1,500. The total amount paid to fishery officers for the year ending June 30, 1877, was $54,251 in addition to the expense of maintaining the fisheries' protective steamer, $17,059 more; in all, $71,310. This is exclusively for the protection and regulation of fisheries, which yielded in this same year products valued at $11,422,502.

demonstrated at the Halifax Convention, and the impossibility of judicious legislation without them, has called my attention especially to the importance of organized action to that end on the part of the government. The Treasury Department is especially concerned in this effort, and indeed it has for many years published an annual statement of the fisheries, which is, however, so imperfect as to be really worse than none. This, however, is not its fault, as there is no provision of law by which these facts can be procured. The attention of the department has, however, been called to this question, and the assurance is received that the proper legislation from Congress will be invoked to make it imperative for the owners and masters of vessels to furnish the desired returns.

I have considered it my duty, as United States Commissioner of Fisheries, to gather as much of the information in question as possible, it being strictly and legitimately connected with the work intrusted to the commission at its original organization by Congress. During the present year my attention has been more urgently than ever turned to this direction as shown in the article on the Halifax Commission. It is now my desire, in co-operation with the Treasury Department, to procure and furnish, *first*, as complete an account as possible of the natural history, including the migrations, movements, rate of growth, character of development, etc., of our principal food-fishes; *second*, the general statistics of the American fisheries, giving the character and amount of catch, number of vessels and men employed, the amount invested, the proceeds of the fisheries, &c. For the better accomplishment of these results the series of circulars, indicated in the foot-note,* and reproduced in full in the Appendix, has been printed by the Treasury Department and circulated in very large numbers. As explained in the article on the Halifax Commission, the first step was to communicate with all the postmasters along the coast, within three miles of salt-water, asking the names of persons known to them as interested in the fisheries. This request met with prompt and general response and furnished a series of

*1. Circular regarding tagged fish in Lake Michigan 1871
2. Memoranda of Inquiry 1872
3. Questions—Food Fishes 1872
4. Circular to accompany "Questions—Food Fishes" 1872
5. Statistics Menhaden Fisheries—Circular 1873
6. Statistics of the Whale Fishery 1875
7. Statistics of Fishery Marine—Circular 1875
8. Blank tables to accompany Circular 1875
9. Statistics Menhaden Fisheries. 2d ed 1875
10. Questions—Food Fishes. 2d ed 1877
11. Statistics Mackerel Fishery, etc. (To accompany "Food Fishes, 2d ed.") 1877
12. Statistics Cod Fishery, etc 1877
13. Statistics Mullet Fishery, etc 1877
14. Statistics of Coast and River Fisheries 1877
15. New York Market Blanks 1877
16. Ocean Temperature Blanks 1877

names that was classified by states, counties, and towns, and to which the circulars were then distributed. Copies were sent also to all the collectors and inspectors of customs, inspectors of light-houses, light-house keepers, and other officials of the government.

The long experience of the Smithsonian Institution in collecting information has shown that it is not well to ask for too much at one time, and that a new circular should not be distributed until the responses to its predecessors have in greater part been received. The result in the present case was even more satisfactory than had been anticipated, though, of course, a large precentage brought no answers whatever. Out of a considerable number a few were so complete and exhaustive as to cover the whole ground, while those of less extent served to give greater minuteness and precision to the details.

The first result of this series of inquiries into the history and statistics of particular fisheries is seen in the report of the United States Fish Commissioner for 1871–'72, in articles upon the bluefish and scup, made by myself; the next appears in the report for 1875–1876, in a memoir upon the American whale-fishery, by Alex. Starbuck, intended to serve as a record of a century's progress in this industry. The historical portion of the work was prepared entirely by Mr. Starbuck himself. His statistics were, however, supplemented and extended by the answers to Circular No. 6, of the series just referred to. In the Appendix to the present report, Vol. V of the series, will be found a monograph upon the history of the American menhaden by Mr. G. Brown Goode. This is a work of 539 pages, and is based almost entirely upon the information furnished in MS. in response to several successive circulars sent out by the Commission. Circulars have also been distributed in regard to the cod, mackerel, halibut, alewife, and smelt; and monographs upon all these species may be looked for in future volumes of the Fish Commission reports. A great deal of information has also been gathered in reference to the natural history of other fishes, among the most important of which is the southern mullet, a fish which in the future is destined to rival the mackerel in industrial and commercial value, and a detailed report upon which will be published at an early day.

In addition to the methods of obtaining information just referred to much has, of course, been gathered by personal inquiry on various portions of the coast, either direct or through agents of the Commission. The results obtained in this relation by Vinal N. Edwards, of Wood's Holl, Mass., have already been mentioned under the head of Halifax Commission.

A proper knowledge of the methods of fishing practiced in other countries having been deemed desirable, I have had translations prepared of sundry articles containing otherwise inaccessible information in reference to the fisheries of Norway and other parts of Europe most closely related to our own. To such as appear in the present volume I proceed to refer.

NOTICE OF ARTICLES RELATIVE TO THE SEA-FISHERIES PUBLISHED IN THE APPENDIX.

Although the United States are not so exclusively occupied with the fisheries as are Norway, Newfoundland, and some other countries, yet, in view of the extent to which the population along the sea-coast and on the lakes is at present engaged in the prosecution of this industry, and considering the enormous aggregate of capital invested and the material results, it is surprising that so little has been done, either by the governments, general and State, or by individuals, in placing the theory and practice of matters connected with our fisheries on a methodical and systematic basis.

Most nations, with the exception of the United States, have the necessary machinery for obtaining statistics of results. Norway, however, is the only nation that has a scientific commission occupied officially in the supervision of the fisheries, and in devising methods by which they may be carried on and extended with the least possible waste. To the labors and observation of such men as Dr. Boeck, Professor Sars, and others is due much of the present efficiency of the Norwegian fisheries.

The United States Fish Commission now proposes, as far as the means are furnished by Congress, to do what it can to place the American fisheries on a proper footing, and to make such observations and suggestions from time to time as may appear to be desirable. With this view it has gathered models of the apparatus used by other nations in its fisheries, some of which embrace features that may be reproduced by the fishermen of the United States to very great advantage.

The fisheries display of the Commission at the Centennial was a first step in this direction, and it is proposed to make this as complete as possible in the reproduction of the exhibition on a much larger scale, whenever Congress furnishes the necessary accommodations.

For the purpose of bringing to the notice of persons in the United States interested the methods and general plans adopted by foreign fisheries, and especially so far as they are novel to our people, I have taken much pains to obtain official information of other nations; and as this relates for the most part to the experience of Scandinavian countries, I have had translated a number of interesting statements and statistical accounts, some of which have been presented in earlier reports, and others will be found in the Appendix to the present volume.

The extent to which this information has hitherto been locked up by the medium in which it has appeared, will be shown from the fact that quite recently Prof. Milne Edwards, an eminent naturalist of France, in publishing an article upon the fisheries of Norway and Sweden, acknowledged his indebtedness to the reports of the United States Fish Commission as containing the only accessible rendering of this important information.

Of all the European fisheries with which the United States is related that of the Loffoden Islands off the northwestern portion of Norway is

the most important, and I therefore have given several articles on this subject. The first of these is a translation, illustrating the general character ot these islands, their physical features, and their natural history. This is followed by the report of Professor Sars of his obervations during the years 1864 to 1877, inclusive, upon the fisheries of the Loffoden Islands, this containing by far the greatest body of information ever published in regard to the habits and natural history of the cod, and its relations to the fishermen and fisheries. It is a storehouse of information of the most important character, and upon its revelations have been based many of the plans of the United States Fish Commission in regard to the artificial propagation of that species.

An article on the general sea-fisheries of Norway, their methods, results, &c., as practiced in 1877, also forms a portion of the Appendix. The original of this pamphlet was distributed at the Paris Exposition as a companion to the fisheries display made by Norway on that occasion.

An article on the geographical distribution of the *Gadidæ* or codfish family, from the German of Dambeck, is also given in the Appendix. This, being mainly a compilation from published records, has many errors, some of which have been corrected; others of less moment have been allowed to pass unchallenged. It gives, however, a very readable and interesting history of the distribution of the cod and its various allied species throughout the various portions of the globe.

The article upon the history of the first five years of the Emden Joint Stock Herring Fishery Association, by Dantzing, contains many important suggestions, which may profitably be borne in mind by American companies organized for a similar purpose. Numerous mistakes made by this association in its early operations, and acknowledged as such in the article, may readily be avoided after being pointed out.

A paper on the sea-fisheries of a portion of Sweden, by von Yhlen, is also instructive. These fisheries are less important than those of Norway, and, while possessing similar characteristics, also have diversities which may be noted by American fishermen to advantage.

In the Appendix also will be found details of a series of experiments made by Commander Beardslee upon the time of exposure needed for correct observations by the Casella-Miller thermometer. I have already explained in previous reports the importance of indications of the temperature of the water at various depths from the surface and the bottom, as illustrating the variations in the appearance of different food-fishes along the coast. It is well established that the movements of the herring, cod, mackerel, and other fishes have a direct relationship to the question of the temperature, and that the occurrence of these fish may, in many cases, be readily anticipated and proper arrangements made for them by studying indications of the thermometer for a considerable time previous. It is therefore of importance to know the method of treatment of the thermometer used in this work; and the experiments of Commander Beardslee have given us the means of making a proper and very necessary allowance for instrumental errors.

F.—PROPAGATION OF FOOD FISHES.

10.—GENERAL CONSIDERATIONS.

A patient whose constitution has been undermined by disease of long continuance is unreasonable in expecting good results and a radical cure after a short application of approved remedies, yet he and his friends may be disappointed if the recuperation from the excesses or lesions of many years is not manifest in as many days. In reality, the reverse is rather the rule, the time of recovery being more frequently much longer than that of the continuance of the morbific influences. The expectations in regard to the results of fish culture are of somewhat the same character. Although decades of years, perhaps even a century, may have witnessed the continuance of agencies for the diminution of fish in our waters, the public mind is unsatisfied, and perhaps inclined to severe criticisms if the recovery of a supply is not appreciable within the first two or three years of effort.

We are, however, clearly entitled to maintain, in view of the experience of foreign countries and our own, that no reasonable anticipation in this respect will be disappointed, and that the proper measures of legislation and of artificial propagation will exhibit a marked result long before the end of the present generation.

In no instance can even the beginning of a success be achieved in a shorter period than four or five years, as the young, especially of the anadromous fish, such as the shad, the alewife, and the salmon, require that period for arriving at maturity. The parent fish are first obtained, the eggs extracted and fertilized, and after being hatched out the young are finally deposited in the waters to take their chances. Whatever be the extent of time during which the progeny remain in the river, they are more or less withdrawn from observation, and it is only when the young fish has reached full maturity and revisits its place of deposit for the purpose of spawning that its presence is appreciated. It sometimes happens, too, that, for one reason or another, the first deposit of young fish proves to be a failure. They may be introduced while in a sickly condition, so that a difference of temperature causes them to succumb; or else in such small numbers that in the presence of an unusual abundance of enemies they may all perish. What special agencies there may be in the ocean after they reach it we are unable to say; but from their wider dissemination their chance of escape is greater.

Again, we may misunderstand the period required for the maturity of certain species. While four years may be considered the general average for cod and herring, five are probably required for the Eastern salmon, and it is not impossible that the California salmon will show itself only after the lapse of six years from its birth. I hope, however, to introduce enough illustrations of even partial success to warrant the attention of Congress and of the States towards the operations of the United

States Commission and those of the respective State commissions. It is very gratifying to note the rapidly increasing interest in the whole business of fish protection and fish propagation shown by the citizens of the United States and culminating in the measures taken by national and State legislatures for fostering whatever looks towards the increase of the fish supply. At the time when the United States Commission was authorized by Congress and organized, the only State fish commissions were those of Alabama, California, Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont, eleven in all, and of these a small number only were provided with funds and power to enforce legislation taking definite action in regard to the increase of a supply. The list now amounts to twenty-six, all provided with intelligent and able commissioners, for the most part with appropriations sufficient to enable them to survey the ground and take the proper steps towards future action. Quite a number of these have their own hatching-houses, in which are hatched out not only the local species, but also such eggs as may be supplied by the United States Commission, especially of the Eastern salmon, the land locked salmon, and the California salmon.

As already remarked, these State commissions, in the aggregate, accomplish a very great deal towards the protection and restoration of their fisheries respectively, and especially in the way of distributing trout and black bass in their local waters. Both of these are fish with which the United States Commission have nothing to do, as they come more particularly within the province of the State organizations.

The states bordering on the great lakes have also accomplished a still greater work in the hatching out and introduction of the young of white-fish and lake trout, the former being by far the most important species of the lakes, and one for the multiplication of which, on a large scale, every effort should be made.

The hearty co-operation of these State commissions with that of the United States is a subject of especial gratification, there being, so far as I can learn, no jealousy whatever, but all working harmoniously towards a common end. This co-operation of the State commissions with that of the United States is exhibited in two ways, direct and indirect. The former is shown in the work of the propagation of the *Salmo salar*, or the salmon of Maine, which has been carried on at Bucksport, on the Penobscot River, by the United States, aided by an appropriation of money by the States of Connecticut and Massachusetts, each receiving its share of eggs in proportion to its investment of $500. The State of Maine has, I believe, made no actual appropriation, but is concerned as requiring by law the introduction into its own waters of one-fourth of all the fish hatched out by foreign co-operation within its borders.

A similar arrangement has been made with Massachusetts and Connecticut in the propagation of the land-locked salmon, both at Sebec, in 1873 and 1874, and at Grand Lake Stream, for several years up to the present.

The State of California has also assisted in the propagation of the California salmon by appropriations made for the most part by public spirited citizens in sums of one or two thousand dollars, in order that the supply, especially intended for the Sacramento, might be increased in proportion, and hatched out at the United States establishment on the McCloud.

The organization of a new establishment on the Clackamas, a tributary of the Columbia River, will be referred to hereafter. All the expense of preparing the building, dam, and apparatus was met by voluntary contributions from the canners on the river, although the actual work was superintended by officers of the United States Fish Commission detailed for that purpose.

The State of Maryland, too, by its fish commission, has also for several years carried on its operations of shad-hatching in connection with the United States Fish Commission, Mr. T. B. Ferguson, the accomplished head of that commission, having placed at the command of the United States Commission the important apparatus devised by him for hatching out eggs, and aided in its practical manipulation. He is also the head of the establishment in Baltimore where the eggs of the California and land-locked salmon have been hatched for distribution by the United States Commission to such points in the Southern States as were without proper facilities for the work.

The indirect aid rendered by State commissions in the planting of fish is also of very great importance.

The present production of the eggs of the California salmon is on so enormous a scale that it would be impossible for the United States Fish Commission, even with a considerably larger appropriation, to undertake the business of hatching them out, or of placing them in the waters of the several States. It is also impossible for the officers of the commission to have a proper appreciation of the character of these waters, which will alone permit a judicious planting. Very great aid is therefore experienced in the general work by the present arrangement of forwarding the eggs of the salmon, of the various species, California, land-locked, and Eastern, to the State commissioners, who receive and hatch them out and personally superintend their introduction into appropriate waters, at the same time making a report of their action in the matter. In many cases, too, the commissioners of one State will agree to receive and hatch out eggs for the waters of an adjacent State which has no hatching-house.

The messengers of the Fish Commission also frequently deliver their young shad to the State commissioners, who take charge of them and see that they are properly deposited, a selection of points being made by correspondence with these officers.

APPLICATIONS FOR FISH.

The applications for the services of the United States Fish Commission, in supplying eggs or the young of fish, may be arranged under two

classes, domestic and foreign, both increasing very rapidly from year to year. All requests of this kind are entered on proper blanks, giving the date of application, the character of fish desired, name of applicant, member of Congress or other person through whom the request is conveyed, the region or spot to be supplied, instructions as to route, railroad or otherwise, by which they are to be shipped; all being information necessary to a proper response.

It is, of course, impossible to meet every call, and a selection of recipients is sometimes necessary, the object being to diffuse the benefits of the commission over the greatest possible extent of country. Accordingly, if an application comes from a locality near the mouth of or low down a current or stream, the actual planting is made at the headwaters of the river, so that the entire stream will receive the benefit. This policy is based on the fact that an anadromous fish, introduced at a given point in a river, is not likely to ascend above that point, on its return from the ocean.

An accompanying table will show the number of calls, and the proportion of the demand for the different species. By this it will be seen that the carp is rapidly becoming the favorite, as its culture is more within the reach of individuals than that of the salmon or shad.*

It is customary for the Commission to request that all applications for fish be made through some member of Congress, who can vouch for the standing of the applicant and the character of the locality to be supplied. It is, of course, impossible for any one resident in Washington to know the persons asking for fish, whether they are responsible parties, and whether they want them for the benefit of the community or for some merely personal end.

The demand from foreign countries for eggs or young fish is also increasing very rapidly and has been met as far as practicable, without affecting the interests of the United States. In most cases, especially that of the California salmon, the only limit to the home applications is, in the first place, the amount of the Congressional appropriation for it, and second, the extent to which the State commissions or clubs devoted to the stocking of particular waters can meet the expense of hatching out the eggs when received, and of introducing them into the waters. For several years past a much larger demand might have been easily met.

******Number of applications for fish.*

1873	19	1876	174
1874	42	1877	254
1875	52		

The following are the different species applied for in 1877:

Shad	37	Trout	12
California salmon	81	Carp	53
Land-locked salmon	56	Tench	6
Whitefish	9		
			254

When, therefore, requests are received from foreign governments the stipulation made of paying the actual cost is cheerfully complied with by them, and a graceful act of international comity is thereby made practicable.

It will not be forgotten by those who have read the reports of the Commission from the beginning that before the home establishments for procuring the eggs of salmon were in operation, the German Government presented 250,000 eggs of the Rhine salmon to the United States, and sent them over in charge of a special messenger. Those that survived were hatched out at the establishment of Dr. Slack, at Bloomsbury, N. J., and introduced into the Delaware River, where some of them are believed to have returned as mature fish to their original starting point.

A portion of the correspondence with foreign governments on this subject will be found in the Appendix under the respective heads of distribution of fish, and the amount of service rendered in reply to applications.

The applications, for the most part, were for California salmon and whitefish from the different provinces of New Zealand, from Australia, Ecuador, Germany, France, and the Netherlands. All have been responded to excepting that from Ecuador, which has no waters suitable for any of the fish included in the operations of the United States Commission.

Apart from direct applications for the fish, numerous requests are on file for help in other ways. I have already referred to the co-operation of the States of Connecticut, Massachusetts, California, Maryland, &c., in the way of joint work in the production of shad, salmon, and the like, and have given the details to a sufficient extent.

A noteworthy instance is shown in connection with the operations for the propagation of salmon at the Clackamas fishery on the Columbia, where an association of canners combined to furnish the sum of $27,000 with which to start a hatching-station in order to maintain the supply. At their urgent request I detailed Mr. Livingston Stone, superintendent of the McCloud River hatchery, to start this establishment by furnishing plans of a hatching-house, dams, &c., and supervising their construction. This was done in the summer of 1877, and a thorough organization was effected, from which it is hoped the yield of salmon on the Columbia River will be continued at its present average. A further account of the enterprise will be found in a subsequent part of the report.

The great success of the methods adopted by the United States Commission for the hatching of fish and of securing the ready return of the fish from the sea to their spawning-grounds, by means of artificial fishways, has induced a large correspondence with foreign establishments, especially with the Deutsche Fisherei-Verein of Germany, the great organization which has in charge the interests of all the German fisheries and composed of some of the most eminent specialists in Germany, and having its headquarters at Berlin. Application was received in the

autumn of 1876 from Mr. J. Bancroft Davis, at that time minister of the United States to the German Empire, requesting that models of certain apparatus be furnished at the expense of the Verein. This was promptly attended to under the supervision of Mr. James W. Milner, and the articles forwarded gave great satisfaction.

A similar application was received from the Japanese Government, to include models, not only of hatching apparatus, but of fishways, to be applied to the waters of that country; and a full series of models, a reproduction of those exhibited at Philadelphia at the Centennial, was accordingly made and presented to the Government of Japan in return for the very valuable donation of the whole of its fishery exhibit at the Centennial.

Mr. A. Eisendecher, of Valdivia, Chili, applied for a statement of probable expenses of placing California salmon and other fishes in the waters of Southern Chili; the United States consul in Ecuador also sought similar information for that country.

Applications have also been received from parties in British Columbia for information as to the best mode of utilizing the refuse and waste of the salmon-canning establishments. Several firms engaged in the canning of lobsters in New Brunswick embraced the occasion of the presence of the Fish Commission at Halifax to call attention to certain difficulties in the preservation of lobsters in cans, some establishments being unable at certain seasons of the year to prevent the entire decomposition of the canned meat, in spite of all precautions. Information in response to this query has been furnished as far as it was at the command of the Commission.

As already explained in earlier reports, the United States Fish Commission endeavors to occupy ground not covered by State commissions or by private enterprise; and whatever species are fully cared for by other organizations are not treated by the United States Commission.

Two favorite fish in the United States, the trout and the black bass, are propagated by hundreds of establishments throughout the country, both State and private, which attend fully to them. They are, however, available only for local waters, private fish ponds, or streams, and there would be a manifest impropriety on the part of the United States Fish Commission in catering to the interest of a few individuals. Both species are of comparatively little account in the food production of the nation, and it is only those who can afford to devote an abundance of leisure to their capture, or those whose means enable them to purchase at a high price, who are benefited by their cultivation. Of course, if the question were as to the introduction of some new variety of these fish that should have some special qualification, and which could only be brought to the notice of the people by the United States Commission, the argument would be very different.

As already explained, the only species that have received special at-

tention on the part of the United States Fish Commission, up to date, are the sea salmon of the Atlantic, *Salmo salar;* the sea salmon of the western coast, *S. quinnat;* the land-locked salmon, a local race of the *Salmo salar;* the whitefish, *Coregonus albus;* the shad, *Alosa sapidissima;* the fresh-water herring, *Pomolobus vernalis* and *æstivalis;* and the German carp, *Cyprinus carpio.* It is intended, however, to devote more or less attention to the cultivation of the smelt, especially the very large, land-locked form found in certain waters in Maine. At no distant day it is hoped that specimens of the Oriental Gourami, a fresh-water fish with many valuable peculiarities, will be added to the list.

It is also proposed to take some measures to introduce the California brook trout to the Atlantic slope, on the ground that this fish will resist successfully a higher temperature of water than the Eastern trout; and although of no great comparative economical value, yet it will furnish to the citizens of the more southern States of the Union a pleasant sport in their capture. The instinct of mankind appears to be to catch fish under all circumstances and conditions, and the introduction of a brook trout into the warmer waters of the United States will be a very popular move.

11.—FACILITIES AND ASSISTANCE RENDERED.

The prompt and hearty compliance with the requirement of the law of Congress, directing the various departments of the government to render such aid as might be in their power to the service of the United States Fish Commission, has been a subject of great gratification, reference to such aid being made in various portions of the present report.

As already stated, the Navy Department furnished the iron steam-tug Speedwell, with a full equipment of officers and crew for summer service off Salem and Halifax. As will be seen by Mr. Stone's report, at one time during the operations at the McCloud River hatching-station, General McDowell, commanding the Department of the Pacific, furnished a detail of one officer and four men for the protection of the fishery against threatened violence. The co-operation of State fish commissions has been mentioned.

I am gratified in being able to say that there has, so far, been manifested no jealousy in regard to the United States Fish Commission, but that everything has been done to strengthen the hands of the Commissioner and to enable him to do efficient work.

Very important aid has been rendered by railroad companies in the transportation of eggs and fish to various parts of the country, there being scarcely an exception to the willingness to grant the facilities asked for in the accompanying circular. Among the earliest companies to extend this aid were the Baltimore and Ohio, the Philadelphia, Wilmington and Baltimore, and the Pennsylvania Railroad Companies. During the year 1877, similar authority was received from forty-two com-

panies according to the list given in the footnote.* The special points asked for were, permission to have the cans containing the young fish transported in the baggage-cars of express trains and to allow such access of the messengers to the same as might be necessary. The provision that no charge was to be made for extra baggage was offered by the companies themselves, and gladly accepted, while an additional privilege was conferred by the Baltimore and Ohio Railroad Company by setting the example of authorizing the stopping of trains at such points on rivers or streams as might be convenient for the proper introduction of the fish into the waters. I am very happy in being able to make public acknowledgment of this very great liberality.

** List of railroads granting facilities in* 1877.

Atchison, Topeka and Santa Fé Railroad Company.
Atlantic and Pacific Railroad.
Alabama and Chattanooga Railroad.
Alabama Central Railroad.
Atlanta and Charlotte Air-Line Railway.
Atlantic and Great Western Railroad.
Baltimore and Ohio Railroad.
Baltimore and Potomac Railroad, and Alexandria and Fredericksburg.
Central Railroad of New Jersey.
Central Vermont Railroad.
Chesapeake and Ohio Railroad.
Chicago, Burlington and Quincy Railroad.
Chicago and Northwestern Railway Company.
Cleveland, Columbus, Cincinnati and Indianapolis Railway Company.
Connecticut River Railroad.
Denver Pacific Railway Company.
Fort Wayne, Jackson and Saginaw Railroad.
Georgia Railroad Company.
Houston and Texas Central Railway Company.
Illinois Central Railroad Company.
Kansas Pacific Railway.
Louisville and Nashville, and South and North Alabama Railroad.
Lake Shore and Michigan Southern Railway Company.
Louisville, Cincinnati and Lexington Railroad.
Missouri, Kansas and Texas Railway.
Missouri and Pacific Railway.
Northern Central Railway Company.
New York, New Haven and Hartford Railroad Company.
Pennsylvania Railroad Company.
Philadelphia, Wilmington and Baltimore Railroad.
Richmond and Danville Railroad Company.
Richmond and Petersburg Railroad.
Richmond, Fredericksburg and Potomac Railroad Company.
Seaboard and Roanoke Railroad.
Saint Louis and San Francisco Railway.
Saint Louis, Iron Mountain and Southern Railway.
Vicksburg and Meridian Railroad.
W. C. Virginia Midland, and Great Southern Railroad Company
Western and Atlantic Railroad Company.
Wilmington and Weldon Railroad Company.
Wabash Railway.

To the express companies, too, especially the Adams and Southern companies, acknowledgments are due for waiving their privilege of controlling the extra freight on certain railroads. In one or two instances serious difficulty was experienced by agents of the express companies insisting upon the right to have the cans of the Commission delivered to them for transportation. This was done in one or two instances and resulted very disastrously in the entire destruction of the fish. Application to the president of the companies, however, secured from them instructions to their subordinates to waive all claims of the kind referred to.

Acknowledgments are also due to certain steamship companies plying between Boston, New York, and various points in Europe for assistance in transporting the messengers and the eggs of fish under their charge, free of expense. When contemplating the transmission of eggs of the California salmon and land-locked salmon and of whitefish to certain points in Europe, the agents of the French Transatlantic Steamship Company, of the Netherlands Steam Navigation Company, and of the North German Lloyds, in New York, agreed to transport the eggs sent abroad free of expense. By reference to a succeeding paragraph, in describing the history of operations connected with the attempted introduction of turbot and sole into the United States, it will be found that very important assistance was rendered by the Cunard line in giving to Mr. Mather, the agent of that transfer, a free passage for himself and fish from Liverpool to Boston. This was primarily through the instrumentality of Mr. J. G. Kidder of Boston, who was among the first to suggest the importance of this transfer and to offer his services in assisting it.

12.—LEGISLATION AND PROTECTION.

A very large part of the correspondence of the Commission is connected with inquiries relating to the jurisdiction of the United States and of the States over the fishing grounds, and the methods by which all parties can secure their rights.

A very decided antagonism exists in this country, as in Europe, between professional fishermen, who prosecute their work by different methods. Attention has been called in previous reports to the Parliamentary investigation in England into the relations between line-, beam trawl-, and net-fishing, as also between fishing by hand-line and trawl-line, and between seines, pounds, and drift-nets. The question as to who possesses jurisdiction over the fisheries proper along the coast of the United States, and in the navigable waters is yet unsettled. At present, the United States does not exercise any, but leaves to the States the enactment of laws on the subject. Some fishermen, aggrieved by the burden of State legislation, threaten to appeal to the Supreme Court for the decision of the question; and it is much to be hoped that before long a test case may be established, so that persons interested

may know whether to appeal for protection and relief to the States or to the general Government.

The subject is still more complicated by the text of the "Washington Treaty," in regard to fisheries, by which citizens of one of the contracting powers are given the privilege of fishing on the inshores of the other; and it is not yet determined whether either party has power to pass any laws restricting the fishery rights on the shores of the other. A case has arisen where the citizens of Massachusetts were interfered with while carrying on seine-fishing on the shores of Newfoundland, and a question of damages is still under jurisdiction. Of course, so far as the setting of traps or pounds obstructs navigation it is clear that the authorities of the United States have power to remove these or to require them to be removed under severe penalties; but so far no special question has been made as to fishing where the interests of navigation are not concerned.

At the Halifax convention great complaints were made by witnesses called in behalf of the provinces, of the use, by the Americans, of trawl- or long lines off their shores, these, in their opinion, tending to destroy the mother fish, while engaged in the act of spawning, and thus affect the supply. It was, however, stoutly maintained by others that these had no material influence upon the result, and that they were necessary to secure a proper harvest of the sea.

Legislation in the United States is being continually invoked for the removal of fish pounds and weirs, and in certain areas at the head of Buzzard's Bay and about Long Island protection has been granted by the State legislatures.

During the summer of 1877 an earnest appeal for the protection of the United States was received by the United States Commission from Block Island, signed by all its fishermen, and I reproduce this appeal in the Appendix to show the feeling on this subject and the general character of the objections to the trawling. Of course, having no jurisdiction in such matters, I can do no more than to publish it in the present case. I propose, in a general treatise on the plans and character of the American sea fisheries, to discuss this whole matter at length.

In regard to the protection of fish and the fishing in interior waters not navigable, it is of course very evident that the States must make the necessary provisions, and if the labors looking towards the introduction of the anadromous fish are to be prosecuted successfully, arrangements must be made for the protection of the fish, securing to them during certain periods free access to the headwaters of the streams and their return therefrom, as well as the establishment of a close time each week during the run, and the absolute cessation of fishing after a certain period. These very reasonable requirements are urged to protect the interest and rights of the many against the greed and senseless rapacity of the few.

The methods necessary for securing the upward run of the fish are

the removal of all unnecessary obstructions, the establishment of fish-ways or fish-ladders over such natural or artificial dams as cannot otherwise be ascended.

It is, however, not less necessary to provide for the return of the young fish to the sea. The most serious obstacle to this is found in the arrangements known as "fish-baskets," intended more particularly for the capture of eels descending the streams in autumn, but taking at the same time immense quantities of shad, alewives, and other valuable fish, including the salmon. This arrangement consists in the establishment of two walls of stone blocks or pebbles, laid up in the form of the letter V, the apex tending down the stream. At the apex is placed what is called a basket, which consists of a box in several compartments, each with a bottom of slats set obliquely. The descending fish that happen to be intercepted in the upper end of the V are carried down and poured into the slatted boxes. The large fish are retained, while some of the smallest pass through the openings. Shad, however, are so extremely delicate that the slightest blow or shock will kill them, and the baskets are sometimes filled with bushels of young shad not more than a few inches in length.

It is useless to undertake to stock rivers with shad or herring in which this objectionable practice is maintained. Fortunately, it is practicable only in waters shallow enough to permit putting up the side walls of stone; but, unfortunately, the Susquehanna, which was at one time one of the finest shad-streams in the United States, is particularly noted for the establishment of fish-baskets, owing to the succession of shallow places in the river traversed with rocky ledges, and having an ample supply of bowlders, furnishing material for the walls. It is quite safe to say that, more than anything else, it is to the presence of these fish-baskets in large numbers that the decrease and approximate extermination of shad in the Susquehanna is due, and that no efforts on the part of the States of Maryland and Virginia for the restoration of shad and herring will be of any avail unless accompanied by most stringent measures for destroying these obstructions.

Another very important subject, to which the attention of the proper authorities should be called, is the enormous drain upon the possible increase of the striped bass or rock-fish by the sale of the young in the markets. This fish, of which individuals weighing fifty to seventy pounds have formerly been seen in the market of Washington, is now rapidly being reduced in number and size, and by no cause, probably, so much as by the capture and sale of fish from six to twelve inches in length. It is more than probable that, if undisturbed, more than half the fish of this size would reach a weight of twenty pounds or more; and no more judicious measure could be enacted than that of imposing a heavy penalty upon any dealer for having in his possession, or offering for sale, striped bass of less than fifteen inches in length, or weighing less than from one to two pounds. Of course the capture by individuals of fish below the

legal limit could not be prevented, nor would it make much difference in the result. It is to the wholesale gathering in, by pounds and seines, of these young fish by the ton, that the decrease in their number is especially to be ascribed.

13.—WORK ACCOMPLISHED IN 1877.

The Shad.

Station on the Susquehanna River.—Reference has been made in previous reports to the difficulty of obtaining a sufficient supply of shad in the Southern waters of the United States to warrant the labor and expense of occupying them, the depletion of most of the streams having been carried to such an extent as to make it almost impossible to find enough spawning shad to commence the work of restoration.

Accordingly, in arranging the plans for 1877, it was determined to concentrate efforts upon the Susquehanna and Connecticut Rivers, in the hope of securing the needed material for the purpose. Another object in this selection of stations was to test, at one of them at least, the efficiency of the new method of Mr. T. B. Ferguson, fish commissioner of Maryland, constituting a radical change in the mode of hatching shad, and overcoming many difficulties attending the use of both the Green and the Brackett hatching-boxes. These, as already explained in previous reports, consist of boxes with wire-gauze bottoms of about one and a half square feet area, fastened in gangs to posts in a running stream. The eggs placed in these boxes receive the influence of the ever-changing current and are hatched out. The young fish also are kept in the boxes until the time for transportation arrives, generally within twenty-four hours after birth.

The protection of the eggs from their enemies is one of the chief factors in this form of apparatus. Many practical difficulties, however, have occurred in the use of these boxes. In streams where the spawning shad can be obtained at some distance above the mouth where there is a constant current, as in the Hudson and Connecticut, some of the principal difficulties are avoided, and the work can be prosecuted for the most part with comparatively little failure. Even here, however, the difficulty of reaching the boxes to give proper attention to the eggs and young fish, the danger arising from sudden freshets, from floating lumber, logs, &c., is very great, and there is usually a very considerable percentage of loss arising from casualties. The difficulties become very much greater, however, when the work is carried on in tidal waters where the current is mainly derived from the flow of the tide, which changes its direction twice a day, with a period of calm between. Even a gentle wind blowing against the tide will also neutralize the current and endanger the result. The boxes, which at one tide are floated in a given direction with the change, are brought round so as to float in an opposite one. In changing, they frequently become entangled, especially in stormy weather, and are upset and the contents spilled out—a result likely to happen at any time with a sudden blow and the conse-

quent agitation of the waves. The period also during which there is no current whatever is injurious to the eggs, and frequently produces serious casualties.

Another objection to the floating boxes is the small number of eggs that they can accommodate in tidal waters, 20,000 being quite a maximum for one. This would make it necessary to employ fifty boxes for the hatching of 1,000,000 eggs, which is by no means a large gathering even for a single day.

The attention of Mr. Ferguson, a gentleman of great mechanical ingenuity, was early directed to the question of the possibility of a more wholesale manipulation of the eggs of shad, and he ultimately devised an apparatus which promised to be of very great efficiency in this respect. In this method the work is done by an apparatus combined with steam machinery, by means of which the eggs receive the necessary mechanical agitation, being plunged up and down in the water, or placed in cones constantly supplied with a current of water coming in from below, and over-flowing at the top, in the latter case the water being derived from a tank at a higher elevation, which is kept filled by a steam-pump.

In addition to these advantages, the work is prosecuted under cover, and the persons engaged are protected from dangers and exposure consequent upon the old-fashioned method.

Early in the spring of 1877 Mr. Ferguson commenced his operations by fitting up three scows or stone boats, borrowed from the city of Baltimore for the purpose, each about 60 feet long and 20 feet broad. One was furnished with the necessary machinery for the work. An arrangement was made with him to hatch out all the fish eggs procured by the United States Fish Commission for transportation to distant waters, their shipment, however, being entirely under the direction of Mr. James W. Milner, the representative of the United States Fish Commission.

One of the three scows was fitted up for the accommodation of Mr. Milner and his party of messengers, and another for Mr. Ferguson's men, and the first locality selected was in the Northeast River at the head of Chesapeake Bay; but as soon as the large seines operated on the Eastern Shore of the bay were discontinued towards the close of the season, a station was taken in Spesutie Narrows, between Spesutie Islands and the Harford County shore, about six miles below the railroad bridge at Havre de Grace, as being more sheltered and more convenient to the center of operation of the gillers, upon whose catch the supply of spawn was dependent.

The work of shad-hatching commenced early in May, the eggs, as stated, being first obtained from fish taken in seines, but subsequently from those taken in gill-nets. The season closed on the Susquehanna on the 13th of June, up to which time there were distributed more than six millions of shad.

The result of this experiment was entirely satisfactory. At much less trouble and expense than usual, this large number of shad were handled

by the Commission, and distributed to appropriate waters, where, it is hoped, their presence will be indicated at the proper time.

Station on the Connecticut River.—The old station, on the Connecticut River, at South Hadley Falls, became the scene of the labors of the Commission after closing on the Susquehanna, the furniture and other equipment being loaded on a freight-car and taken directly through to their destination. A house in the vicinity of the fishery was hired for the accommodation of the party, and the first fishing commenced on the night of the 26th of June. The operations were continued here until the 4th of August, eggs being taken nearly every night, the entire number amounting to something over three millions.

As this station was within the jurisdiction of the State of Massachusetts, it was necessary to obtain permission from its commissioners to carry on operations, which was obligingly granted on the condition that they might nominate some one to be present during the season, to see that the regulations of the State were fully carried out. Mr. Charles G. Atkins was selected for this work, and had the superintendence of a certain portion, under the general direction of Mr. Milner, who had charge of the whole.

Here floating boxes were used entirely, and some of the difficulties referred to on a previous page, were experienced, especially in the interference of a raft of logs floating down the river over the spawning-ground.

For the purpose of studying the physiological condition of the eggs and young while in the hatching-boxes, the services of Mr. H. J. Rice of the Johns Hopkins University, Baltimore, were secured. This gentleman had been employed previously at Havre de Grace during the operations of the United States Fish Commission, and an account of his results has already been published in the general report of the Maryland Fish Commission. Mr. Atkins, too, made a great many interesting observations in regard to the hatching of eggs, &c.

The number of eggs procurable at South Hadley Falls not being so great as desired, Mr. Frank N. Clark was sent to Windsor Locks in Connecticut, to a station where it was said spawning shad were to be obtained in abundance, but the season was so far advanced that he did not consider it expedient to commence any work there. There is good reason to believe, however, that it will repay the effort if undertaken at the proper time.

A detailed statement, by Mr. Milner, of the shad-hatching operations during the year will be found in the Appendix, including an account of the precise disposition made of the fish from the several stations.

The Pacific Salmon.

The Columbia River or Clackamas Station.—A remarkable deficiency in the yield of salmon in the Clackamas River in 1876 aroused the persons employed in the canning trade on the river to use all practicable measures of relief. A company, entitled the Oregon and Washington

Fish Propagating Company, was incorporated for this purpose, with Mr. John Adair, jr., as president, Joseph G. Megler, secretary, and Henry ———, treasurer. The capital stock was placed at $30,000 in 600 shares.

At the request of the officers of this company, warmly indorsed by Senator Mitchell, of Oregon, I instructed Mr. Livingston Stone to anticipate the time of his usual visit to the McCloud River, and to proceed to the Columbia for the purpose of starting the enterprise. Accordingly, he reached Portland on the 11th of June, and had a consultation with the directors of the company. A visit by Mr. Stone, the year before, for a similar purpose, resulted in his choice of the Clackamas as the most suitable spot; but as this was not at the time satisfactory to the company, five weeks were spent in carefully examining all the localities along the river. It was found, however, that some objection applied to every other possible station. Thus the waters of the des Chutes, though abounding in salmon, could not be prepared for hatching purposes. Others had no fish, and others still were too distant and inaccessible. The Indian troubles prevented any recourse to the nearer waters of the Salmon River, or to the tributaries of the Upper Columbia.

One objection to the Clackamas was that fish found there were not believed to be the genuine Chenook salmon, but on finding that this was a mistake, and that the desired variety was actually the fish occurring there, it was finally concluded to fix upon the Clackamas, and Mr. Stone was authorized, on the 5th of July, by the treasurer to select it as the location. He accordingly located the hatching-station on the south bank of the Clackamas, just above the mouth of Clear Creek. The plans having been completed, their execution was placed in the hands of Mr. Waldo Hubbard, an employé of the Fish Commission, who carried them out with great promptness and efficiency, and, although encountering some unexpected difficulties, the hatching-house was finished with a capacity for a million eggs.

Various obstacles presented themselves from time to time, but finally 200,000 eggs were secured and placed in temporary boxes. Unfortunately, however, a sudden rise in the river carried away the rack across the Clackamas, the Indian trap used for a corral to confine the fish, and finally the eggs placed in the boxes. Vigorous efforts, however, succeeded in retrieving this disaster in part, but it was not until the 25th day of September that everything was completed and in working order.

Other preparations, however, had to be made for the purpose of protecting the buildings and apparatus from the sudden rise of the river; and for this a large boom was built which it is hoped will answer the purpose.

The total number of young salmon hatched out during the season was about one million, a portion of the eggs having been transferred from the McCloud River.

Mr. Stone found that the number of nets stretched across the river constituted a very great impediment to the ascent of the fish, making

it probable that unless this could be prohibited by law it would be useless to attempt artificial propagation. It is now understood that a law has been passed which will give the relief; and the predominant interest being in favor of protection, it is likely it will be duly exercised.

A full report by Mr. Stone, of his work on the Clackamas, will be found in the Appendix.

The McCloud River Station.—The success of the operations on the McCloud River during the year 1877 was equal to the average of that of the preceding years, although prosecuted under some especial embarrassments. A difficulty with the squatter, who claimed prior rights, gave much trouble to Mr. Stone, and made it necessary for him to secure the assistance of a guard of soldiers detailed by General McDowell for the purpose. This detail of a Lieutenant and four men, reached the United States fishery station on the 16th of August.

The extent of operations at the fishery was interfered with on account of the upward ascent of the fish being prevented by the nets for taking fish at the canning establishments near the mouth of the river, and it became necessary to invoke the action of the California Fish Commissioners in enforcing the State laws prohibiting such fishing after the first of September. Some of these persons were tried and on conviction fined to the amount of nearly a thousand dollars. This broke up the illegal action; but in the mean time the run of the fish for the season had nearly passed.

By the utilization of all the means at his command, as already stated, a fair supply was secured, the first eggs being taken on the 28th of August, and the last of the regular season on the 19th of September. The experiment, tried for the first time in 1876, of chartering a refrigerator car for the purpose of sending the eggs eastward, was again made in 1877, with perfect success. The car left Redding on the 2d day of October, for Sacramento, and reached Chicago on the 7th, the crates containing the eggs being forwarded thence by express. The car contained 39 crates for distribution in the United States, and 12, of 25,000 each, for Europe.

On the 7th of October the eggs for New Zealand and Australia were sent forward to San Francisco, and were shipped by the steamer of the 9th of October.

The necessity of keeping up a supply of fish in the Sacramento River was met by the introduction of two millions of fry, hatched at the McCloud establishment. Such action, if continued for a number of years, cannot fail, in addition to the natural product, to maintain the stock at a fair average. It is believed, indeed, that the increased number in the present supply of fish in the Sacramento, is derived from the young introduced by the United States Commission during its operations for several years past. Without this action the river would yield so small a number as to render it practically worthless as a salmon stream.

In general, the total loss of eggs in transportation did not exceed $2\frac{1}{2}$

per cent., with the exception of those sent to Europe, of which mention will be made hereafter.

Nearly all the fish commissioners of the Eastern States reported the arrival of their quota in most admirable condition.

In the Appendix will be found the detailed report of Mr. Stone upon the work of 1877. In this is a very important series of indications of temperatures. From this it will be seen that during the season, when the eggs were being embryonized for shipment, namely, from August 28 to October, the temperature of the water varied from 48° to 58°, that of the air occasionally rising to 100°. The hatching was completed, however, with the water a few degrees lower.

The total yield of the season up to the 9th of October was a little over 7,000,000, about 1,000,000 more being taken afterward. The distribution of these eggs was made to twenty States, in addition to which a supply was sent to Germany, the Netherlands, England, France, Canada, Australia, and New Zealand. The total number of fish distributed from the various stations amounted to 6,983,000.

Foreign distribution of eggs of the Pacific salmon.—The very high estimation of the California salmon by the fish-breeders of the United States, based upon its hardiness, freedom from disease, rapidity of growth, voracity of feeding, &c., excited much attention among specialists in this line in Europe, and in the summer of 1876 application was made in behalf of Dr. Friedenthal, minister of agriculture of Germany, through the German commissioner at the Centennial, for the transmission of a supply of eggs of this fish. Similar requests were made by the officers of the Deutsche Fischerei Verein, an institution standing far in advance of all others in Europe organized for the protection and improvement of the national fisheries.

It was impossible to meet this call in 1876, but in 1877 arrangements to that effect were made, after an extended correspondence. Mr. Fred Mather was selected to accompany these eggs to Europe, it being understood that his expenses were to be paid by the German Government and the Fisherei-Verein. No charge was made by the United States for the eggs, their donation being considered right and proper, in view of the fact that Germany had presented, in 1873, 250,000 eggs of the Rhine salmon to the United States.

It was arranged that Mr. Mather was to meet the eggs at Chicago, and that no portion of his expenses from that point to Germany and back to New York was to be chargeable to the United States.

On the 7th of October, 1877, a refrigerator car from California reached Chicago with its precious freight of salmon eggs, and Mr. Mather, who was in attendance, received two crates of eggs for England, to be sent to Frank Buckland; two crates for France, for the Société d' Acclimatation, Paris; two crates for the Deutsche Fischerei-Verein, Germany; two for Dr. Friedenthal, minister of agriculture in Germany; and four for

Holland, care of C. B. Bottemanne, Royal Zoological Garden, Amsterdam.

Each crate contained 25,000 eggs, packed according to the usual method. Mr. Mather accompanied these eggs to New York, and as the German steamer did not sail until the 13th of the month he thought it advisable to take them to his house in Newark, where they could be stored in a cellar and properly protected. He had arranged to repack these eggs according to a method of his own devising, and had transferred 25,000 to their new crates when he was instructed, by telegraph, not to interfere with the packing they had received, it being thought that the risk involved would be greater in making the change.

The vessel selected for the shipment was the Mosel, of the North German Lloyds, Captain Neinaber in command, the company having offered every facility for the carrying out of this important experiment. A supply of ice was procured, and the eggs were placed in the forward hatchway on the main deck, properly packed to prevent injury. The proposition to surround the eggs with a lot of straw was not carried out, owing to the fear on the part of the captain of danger from fire. Although notice of the probable time of the arrival of the vessel at Southampton was telegraphed from New York, the messenger of Mr. Buckland, for some reason, did not reach that place until after the steamer had left for Bremen, and his quota of eggs were accordingly added to those for Germany.

The vessel was met at Bremerhaven by Dr. O. Finsch, curator of the Bremen Museum, in behalf of the Deutsche Fisherei Verein; by Director Haack, for Hüningen; by Mr. Heck, of Amsterdam, and Mr. Schreiber, of Hameln, who took charge of their respective packages. Perhaps in consequence of the situation of the eggs on the ship, all except those that had been repacked by Mr. Mather were in bad condition, so much so, indeed, that but few of them survived. Of the 25,000 repacked for Germany, only 396 were lost, proving the efficiency of Mr. Mather's method. Nearly all the remaining eggs were dead, or died soon after being transferred to the hatching-houses, a small percentage alone yielding any fish. Considerable vexation was expressed, by the fish-culturists of Germany and Holland, in regard to what they considered the impracticable method of packing the eggs adopted by Mr. Stone; but there is every assurance that if they had been placed under more favorable circumstances in the vessel, they would have gone through safely, as will be seen by the account of the shipment to New Zealand of eggs packed in precisely the same way, which reached their destination in good condition, after a voyage of eight weeks instead of two, the percentage of loss being very trifling.

In the Appendix will be found a detailed account by Mr. Mather of his experiences.

Fifty thousand eggs were taken by Mr. Mather for the Société d'Ac-

climatation, Paris, from Chicago to New York, and forwarded by the French Transatlantic steamer, arriving in unsatisfactory condition.

It is proposed to renew the shipments of eggs of California salmon to Europe in 1878, when, it is hoped, the experience gained will be available in securing their safe delivery at their destination.

The Atlantic Salmon (*Salmo salar*).

The Bucksport, Maine, Station.—The cessation for the past year or two of operations at Bucksport looking towards securing eggs of the Atlantic salmon, has already been explained, on the ground of a desire to ascertain by the first experiment whether it would be possible to restore this fish to depleted waters, and to introduce them into streams where they had not previously occurred. No very positive results were presented in the early part of the year 1877, up to the time when it would be necessary to make proper provision for securing the parent fish. If, however, the salmon returns in any positive numbers to the waters which have been the subject of experiment hitherto, efforts will be made, with a suitable appropriation from Congress, to renew the work in 1878, on as large a scale as may be practicable.

Results obtained for labor of previous years.—It is, however, a fact, that in November of 1877, a mature female salmon was taken in the Delaware River, in the vicinity of Trenton, and presented by Mr. H. J. Reeder, one of the fish commissioners of Pennsylvania, to the United States Fish Commission. It is now on exhibition in the National Museum in the case devoted to the display of the results of artificial fish propagation. Mr. Reeder, in sending the specimen referred to, remarks that numerous rumors in regard to the occurrence of this fish in that river had previously come to his notice, and that the more authentic one was in regard to a salmon taken in a shad seine in the Delaware, and eaten as the first caught there. A second specimen was said to have been taken at Lambertsville, and another at Carpenter's Point, near Port Jervis, caught in a fish-basket, and weighing 8½ pounds. Other cases were heard of, but in less detail.

Mr. Reeder is of the opinion that the salmon recently taken in the Bushkill could not have been the progeny of the spawning of 1871, as those were hatched in the Hudson River and brought, ten thousand in number, to the Delaware, nearly all dying on the way. About one thousand were placed in the water in a weak and greatly enfeebled condition, and there is no reason to believe that any of them survived.

In 1872 the State commissioners hatched out a number of eggs in a spring run, near the Bushkill, and about 10,000 young fish were planted in that stream. In 1873, about 25,000 were hatched on the banks of the Delaware and turned directly into the river itself. Mr. Reeder thinks that those placed in the Delaware could not have gone into the Bushkill, and that consequently the hatching of 1872 must be considered as the starting point of the specimen captured.

The question, however, as to the precise origin of the fish sent by Mr. Reeder and the others referred to by him is complicated by the fact that in 1872 the Bureau of the German Fisherei-Verein made arrangements for the presentation to the United States Government of 250,000 eggs of the Rhine salmon, obtained at the imperial establishment at Hüningen, and I purchased 500,000 in addition from Mr. Schuster, of Freiburg. When these had been properly brought forward in the respective establishments of Hüningen and Freiburg, they were placed in charge of Mr. Rudolph Hessel, now the superintendent of the United States carp ponds in Washington, and transferred to New York. Owing to the unseasonable warmth of the winter and to the absence of ice, these eggs could not be kept down to a sufficiently low temperature, and on arriving at New York it was found that the greater part had perished. The remainder were taken to the establishment of Dr. J. H. Slack, at Bloomsbury, N. J., and by diligent care on the part of Mr. Hessel about 5,000 were saved and hatched out. These were placed in the Muscanetkong, a tributary of the Delaware, in the spring of 1873.

According to Dr. Hudson, a salmon, weighing 18½ pounds, was taken in a gill-net near the mouth of the Connecticut on the 8th of June, 1876, and sold in the Hartford market for the sum of $10. A few were also seen in the summer of 1877.

The results of the experiment were more satisfactory in the Merrimack River than in either the Delaware or the Connecticut, as a considerable number made their appearance at the Lawrence fishway early in June, and at Manchester on the 13th of June. Quite a large number in all were noted, and the commissioners of Massachusetts and New Hampshire are determined to press the business of restocking the Merrimack with great vigor. A full-grown salmon was seen at the Lawrence fishway on the 3d of October, representing a later run during that month.

The Land-locked Salmon.

Grand Lake Stream Station, Maine.—The work of gathering and forwarding the eggs of land-locked salmon, during the season of 1877–'78, was, as heretofore, in charge of Mr. Charles G. Atkins, at the establishment on Grand Lake Stream, in Eastern Maine, the methods being similar to those of previous years. A series of stakes and fine meshed nets was set on the gravelly shoals below the dam of the outlet of Grand Lake, enough to entrap the whole run of breeding-fish. The eggs were brought forward in the old hatching-house at the spring on a little brook, a tributary of Grand Lake Stream.

The report of Mr. Atkins, as submitted in the Appendix, will explain all the details connected with this work, illustrated by a diagram of the grounds.

As in previous years, the State commissioners of Massachusetts and Connecticut co-operated with the Commissioner of the United States in carrying on the work, the division of eggs being made *pro rata*. The

total number obtained was 2,159,000, the number distributed being about 1,400,000. The remainder were hatched out and restored to the water of Grand Lake Stream. The eggs for the most part reached their destination in good condition, and were successfully hatched out. The table accompanying Mr. Atkins's report shows the precise location of the planting of the entire lot. In addition to the distribution of land-locked salmon made to various portions of the United States, 25,000 were sent to the Deutsche Fisherei-Verein in Germany and 55,000 to the Société d'Acclimation in Paris. Unfortunately, both lots were apparently so far advanced in development that it was impossible to retard their hatching until their arrival at their destination, and consequently all perished.

Lake Ontario Station.—It is well known that not many years ago salmon abounded in Lake Ontario, and that there were many important fisheries for them both on the Canadian and American shores. Of late years they have been exterminated on the American side, and were nearly extinct on the Canadian at the time when Mr. Samuel Wilmot began his celebrated experiments at Newcastle. These fish were in the habit of entering the short rivers, tributaries of the lake, at the proper season, for the purpose of spawning, and after remaining a short time returned to the lake. It was formerly supposed that all these fish came up in the spring from the ocean, by way of the Saint Lawrence River, returning in the autumn or winter. But Mr. Wilmot quite reasonably insisted that they never left the waters of Lake Ontario, and were in every respect to be considered as land locked salmon, corresponding to those of Sebago Pond and various other ponds along the coast of Maine, as also in similar localities in Nova Scotia, New Brunswick, and Quebec.

Mr. Wilmot, from a single pair of breeding fish, occurring in a small stream, on which his hatching establishment is placed, and not more than a few feet across, now counts breeding fish by thousands. But the somewhat remarkable fact is developed that with all this certain increase in number but little impression has been made upon fish as an article for market purposes, it being found impossible to take them at the proper season. Mr. Wilmot's plan is now to place salmon in the waters of the north shore and in the interior, in the hope that in the future desirable river fisheries may be established. No increase in the number of salmon has been noted in the Upper Saint Lawrence, the fish being still taken, however, in considerable numbers in the lower part of the river. I have not been able to ascertain whether any are obtained as high up as Montreal and between that and the outlet of the lake.

Mr. Wilmot having very kindly offered to the United States Fish Commission 5,000 impregnated eggs from his hatching establishment at Newcastle, they were placed at the command of the New York fish commission, by which they were turned over to the New York Aquarium, and there hatched out. By the instructions of Mr. Roosevelt, 4,500 of these young fish were placed in Otsego Lake, at Cooperstown, in June, 1877. As this lake constitutes the headwaters of the Susquehanna River,

we may have here a new source of supply to that stream. It had been the original intention to place these fish in Skeneateles Lake, but for various reasons Otsego Lake was preferred.

Whitefish (*Coregonus albus.*)

Northville (Mich.) Station.—It not being convenient to undertake specially the gathering and artificial impregnation of the eggs of the whitefish, arrangements were made with Mr. Frank N. Clark, of Northville, Michigan, to secure and bring forward such a number of eggs as might be needed by the Commission to meet the comparatively small number of applications, the most important of these being from California, Nevada, and several foreign countries. Accordingly, 500,000 eggs were shipped to Mr. B. B. Redding for the California commissioners. The shipment of the eggs was quite successful, a comparatively small percentage failing to develop. The eggs were packed by Mr. Clark between layers of mosquito netting, and Mr. Redding reports that where the layer of netting was single the eggs were in good condition, but where they rested on a fold or turn they were generally killed, thus suggesting an important precaution under these circumstances. The young fish thus obtained were for the most part placed in Lake Tahoe.

Desirous of trying the experiment of the introduction of our whitefish, *Coregonus albus*, into Germany, I instructed Mr. Clark to put up and forward to Mr. Fred. Mather, for shipment to Germany, a package of 50,000 eggs. These were started on the 18th of January, 1878, and on the 21st Mr. Mather acknowledged their receipt at Newark. As no steamer was up for Germany until the 26th of January, Mr. Mather kept the eggs in his cellar at a temperature of 46°, a piece of ice being allowed to melt continually on the top of the box. The authorities of the North German Lloyds having, with their usual liberality, agreed to forward these eggs without expense, they were placed by Mr. Mather, on the 26th, in charge of the first officer on the Mosel, by whom they were put in a part of the vessel which, unfortunately, proved to be too warm for them, as, on their arrival in Germany, all were found to have perished.

Through the mediation of the United States Fish Commission, arrangements were made between the Government of New Zealand and Mr. Frank N. Clark for a supply direct of embryonized eggs of whitefish. This commission was satisfactorily executed by Mr. Clark, and the eggs duly placed on board the steamer at San Francisco, and reached their destination in good condition. A large percentage was hatched out, and the young placed in antipodal waters.

The European Marane Whitefish (*Coregonus marœna*).

The value of the Coregonus or whitefish as an article of food and as a subject for artificial propagation is becoming appreciated in Germany, as it is in the United States; and the German fish culturists are especially active in experiments and suggestions. A favorite species is what is known as *Madue Marœne* or *Coregonus Marœna* of (Bloch.) This is found

only in a few lakes in the provinces of Pomerania, Brandenburg, and Holstein, and for the most part in Madue Lake.

The most successful cultivator of this species is Mr. R. Eckardt, the proprietor of a flourishing fish-hatching establishment at Lübbinchen, near Guben, in Silesia. This gentleman, desirous of making some return in behalf of his compatriots for the good will of the United States Fish Commission, in supplying eggs of useful food fishes to Germany, offered to present one thousand embryonized eggs of this species, if he could be advised of the general result of the experiment. This being promised him, a package, said to contain a thousand, was received through the kind offices of the North German Lloyds, in New York, and sent by arrangement to the fish commissioners of Michigan, who promised, after hatching them out, to place the young in some isolated lake in that State, where their future could be followed. Of the number received, 409 were hatched out, and on the 14th of April, were placed in Lake Gardner, a small, deep lake in Otsego County, Michigan. There were believed to be no other whitefish, nor any predaceous fish of any kind in the lake. It is to be hoped that should this lake be found to contain any whitefish, the fact will be duly reported to the United States Fish Commission. This transmission of eggs was accompanied by special instructions as to treatment. Thus they were not to be transferred suddenly to new water nor to water of specially different temperature; but the box must be placed unopened in the water and allowed to remain in that condition for at least an hour. As the skin of the egg is very delicate, of course careful handling is required. In Germany the eggs hatch out from the end of February to the middle of March, this depending on the temperature.

Mr. Eckardt advised that the young fish be placed in the ditches or ponds within one or two days of hatching. In May or June, in Germany, the young fish are said to make their appearance on the shores of the lake.

The Carp (*Cyprinus carpio*).

The introduction of the best varieties of carp, particularly those reared in Germany, has, as is well known, been for many years a favorite object with the United States Fish Commission, this fish possessing many special qualities fitting it for great usefulness in certain portions of the United States. The carp, from having been cultivated for hundreds, and, perhaps, thousands of years as a domesticated fish, and being of all known fish the most readily propagated and reared, takes rank in this respect with poultry and domestic animals generally. It is maintained by German writers that a given area of carp ponds will furnish a vastly greater amount of animal food than can be obtained on the same ground from the cultivation of crops fed to domestic animals; this, too, at much less labor and expense. In some parts of Europe vast areas are occupied in the culture of carp, Prince Schwartzenburg of Austria having, it is said, no less than 20,000 acres occupied in this culture.

The propagation of this fish is prosecuted on every imaginable scale, from that just mentioned down to a tank holding not more than a few cubic feet. In China, indeed, it is said that carp are reared to a very great extent in ordinary washtubs and fed with vegetable refuse.

In Germany, again, there is a regular alternation on the same ground, from carp cultivation to that of the cereals or other plants, and after a certain number of years the ponds are drawn off, allowed to dry and seeded or planted until one or two crops are obtained, when the water is again turned on and the carp reintroduced.

There are several species of American *Catostomidæ* which might in all probability answer in some measure, if not fully, in place of the carp. Among them are especially the buffalo fish, a large sucker, the flesh of which is much esteemed. As, however, some special varieties of carp have been developed and had their instinct of domestication established, while experiments on our indigenous species are scarcely yet tried, there is no reason why time should be lost with the less proved species.

In carp culture quite a number of varieties are known. The species in its original condition is not very different in shape from a gold-fish, and is of an olivaceous color, and distinguished by four barbels about the mouth, these being inappreciable or wanting in the gold-fish. Where the carp is kept in ponds, and where its habits are necessarily sluggish, the body is thick and stout, and the fish tender and delicate. In running water, however, the back is sharper and the body more slender, the result of increased muscular activity consequent upon different surroundings. The two principal varieties of carp produced by cultivation are the mirror and the leather carp. In the mirror carp all the scales of the body have disappeared, with the exception of a few scales along the vertical outlines, and those along the lateral line. The leather carp goes a step beyond this, and is destitute of all scales excepting a few along the line of the back; sometimes they are entirely wanting. The difference between the two, however, is not very great, both being considered much superior to the scale carp, which is best known. It is stated that the cross between the *Cyprinus carpio* and the Prussian *C. carassius*, as also one between the gold-fish and *C. carassius*, are all known as carp; and the fact that they all represent the greater part of the fish of that name in France and England, has given the idea of the inferiority of the carp. It is only in Germany that the different branches are kept distinct and their comparative merits appreciated. The best of these are said to be of very superior quality, ranking with the European trout in point of price and estimation; indeed, it is on these in the interior of Germany that the population depend very largely for its supply of fish needed for church requirements and the general wants of the table.

As already stated, I have for a long time attached much importance to the introduction of carp into the United States of America, as supplying an often-expressed want of a fish for the South, representing the

more Northern trout, and capable of being kept and cultivated in ponds. In the carp this desideratum is amply met, with the additional advantage that the same water will furnish a much larger amount of fish-food in the aquatic plants, roots, seeds, &c., to be found, while feeding may be accomplished by means of leaves, seeds, pieces of cabbage, and lettuce, by crumbs of bread, or by boiled corn and potatoes, or other cheap substances. Of course, among fishes, as among land-animals, sustenance is derived either primarily or secondarily from the vegetable kingdom. The carnivorous trout and black bass find their food in the form of the *Cyprinidæ* or other fishes, or insects and worms, which either directly or indirectly have been fed from plants. In the case of these fish, therefore, we change, first, the vegetable substance into animal, and feed the animal to the carnivorous fish, to a very great disadvantage. In the case of the carp, the plant substance goes directly to the formation of the eatable fish, and produces a much larger yield of flesh.

The growth of the carp, in view of its sluggish, semi-domestic nature, is very rapid, and it is not at all uncommon for the fish to attain a weight of two or even three pounds by the end of the second year, this depending somewhat upon circumstances. In the coldest regions the fish buries itself in the mud during the winter, and of course experiences no growth during this time of seclusion. In more southern portions of the United States this hibernation would not take place, and the fish by feeding throughout the entire year would experience a proportional increase of weight.

There is no ditch, or pond, or mill-dam, or any muddy, boggy spot capable of being converted into a pond of more or less size, that will not answer for this fish. Except for unforeseen casualties, I fully believe that within ten years to come this fish will become, through the agency of the United States Fish Commission, widely known throughout the country and esteemed in proportion.

The earlier reports of the Fish Commission contain accounts of what has already been done in the matter of introducing the carp, and the results of several unsuccessful or unsatisfactory trials are recorded. Not discouraged, however, by failure, the experiment has been continued, and I am happy to announce as a result that a sufficient supply of the three principal varieties has been secured.

The first experiment by Mr. Hessel during the present year, or rather during the winter of 1876–'77, was not successful, the fish being all destroyed in consequence of a storm of unusual severity to which the vessel was exposed in its trip from Bremen to Baltimore. He, however, immediately returned to Europe, bringing a supply of fish to New York in the month of May. There being no suitable locality under the immediate direction of the United States Fish Commission, arrangements were made with Mr. T. B. Ferguson and the commissioners of Druid Hill Park for their accommodation in ponds prepared expressly for their re-

ception, in the vicinity of the State hatching-house in that park; and on the 26th of May Mr. Hessel placed there 227 naked and mirror carp and 118 common carp. These were placed in charge of Mr. Hessel, under the general superintendence of Mr. Ferguson.

The ponds originally constructed by the park commissioners not being sufficient to accommodate the fish, they authorized the excavation of several others, at an expense of $1,000, and it is expected that these will be finished at an early day. As, however, even with this extension, the quarters for the breeding-fish were not sufficient, the suggestion of Mr. Hessel that application be made to Congress for the use of the Babcock Lakes in the Monument Lot, in the city of Washington, was acted upon, and towards the end of the year authority was given by Congress for the use of the Monument Lot for the purpose in question, and an appropriation of $5,000 made for the proper construction and arrangement of the water under the direction of Colonel Casey, superintendent of Public Buildings and Grounds. This work has been commenced and will be finished probably in the course of the coming spring; and whenever it can be done, a portion of the carp and other fish will be brought over from Druid Hill Park ponds, so that the experiment may be carried on in the two localities.

The Monument Lot ponds contain about six acres each. They will be drained off and the bottom leveled and ditches prepared similar to those suggested in Mr. Hessel's article on carp ponds in a previous report. A low place, now perfectly bare at low water, and in the vicinity of the two ponds can, with little expense, be reclaimed and made to add another pond of twelve or fourteen acres.

It is proposed to establish on the island in the west pond some small inclosures for the breeding-fish.

Considerable discussion has arisen as to the person to whom the introduction of the carp into America is due; indeed, it is claimed that this was done many years ago. Certain fish-ponds on the Hudson River are said to have been emptied of their contents by a sudden freshet, and, as a consequence, the Hudson is now full of what is called the carp and sold as such in the New York market. I have not yet, however, been able to find a single fish among those sold as carp which is really any other than the common gold-fish, reverted to its original normal condition. Indeed, in the olivaceous fish caught in great numbers in the Hudson there are usually found precisely similar specimens of white, red, and all intermediate conditions. While, therefore, I cannot say that no genuine carp were transferred to the Hudson, none have come under my observation; and it has occurred to me as possible that the Prussian carp, *Cyprinus carassius*, L., may have been the one introduced, or possibly the hybrid progeny of this and the true carp may have been gradually mixed with the gold-fish.

Some years ago Mr. Poppe, of Sonoma, Cal., brought from Germany some half-dozen specimens of scale carp, and has since made a thriv-

ing business by the sale of fish for breeding purposes. Mr. Poppe has kindly sent me some specimens of his fish. These are scale carp, apparently somewhat hybridized; at least, they do not present the characteristics of the pure breed brought by Mr. Hessel. Information in regard to any other experiments in this direction will be gladly received, especially if accompanied by specimens of the fish for the identification of the variety.

The European Tench (*Tinca vulgaris*).

Fully appreciating the tenacity of life of the tench, and the readiness of its acclimatization in foreign waters, as shown by the prodigious success of experiments with it in Australia, I requested Mr. Hessel, on his return from the last trip to Europe, to bring with him as large a number as possible; and these have also been placed in Druid Hill Park. The especial value of this fish is in the fact that as the water in a given pond dries up or flows off, it buries itself in the mud, and if this is kept sufficiently moist it will remain in perfectly good condition, while, perhaps, the ground above it may become hard and parched, requiring only the return of the water to its bed to permit its emergence. Indeed, it is said that in some places when the pond is dry and the fish is needed, it is dug out like potatoes from a hill. The fish will be distributed together with the carp, as there is nothing incompatible in their occupying the same waters.

A few special varieties of what is known as the golden tench were obtained, and will be propagated; but they have no special value beyond their abnormal color.

The Golden Ide (*Idus melanotus* var. *auratus*).

A large cyprinoid fish in Germany, known as *Idus melanotus*, attaining sometimes a weight of three or four pounds, has, within a few years past, been developed into a golden or red variety, corresponding with that of the gold-fish, but much more beautiful in shape and larger in size. As compared with the gold-fish it has the merit of swimming about on the surface of the water, and being more active in its movements. Mr. Hessel brought with him on the trip just referred to, a large number of the ides, the increase from which will also be distributed in due course of time.

The Sea Herring (*Clupea elongata*).

The question of the propagation of the sea herring (*Clupea elongata*) is one of considerable economical importance, although less prominent in this country than in Europe, as its capture does not occupy so large a part of the American fisheries. Here its most important application is as fresh bait for cod, halibut, &c. The fact that herring eggs are very adhesive, and attach themselves firmly to all objects which they touch, makes it impossible to apply the same methods as with the salmon and the shad, the eggs of which are non-adhesive to each other or to other

substances, and can readily be manipulated by the approved apparatus. Indeed, it has been found that wherever the eggs of the herring adhere in bunches the central eggs almost always fail of development.

The details of the operation of spawning among the sea herring are not well ascertained, but probably are prosecuted as with most fishes, the fish, either in pairs or in masses of both sexes, coming together and discharging the eggs at intervals, accompanied by a discharge of the milt. This being done in the open sea, the eggs are immediately carried off by the current, and ultimately fall to the bottom, unless they happen to come in contact with some substance floating in the water. Where vessels are anchored on the spawning-grounds of the herring it is very common for the eggs to attach themselves to the cable, sometimes increasing its thickness many fold.

During a visit in 1872 to the spawning-grounds of the sea herring at the southern end of Grand Menan, I found, in working the dredge, that sea-weed and pebbles brought up at depths of from five to twenty or thirty fathoms or even more were thickly studded with single eggs of the sea herring, rarely more than two or three being close together. These circumstances were most favorable for development, while their adhesion saved them from many of the dangers of destruction by fishes, &c., to which floating eggs are liable. The experiment of artificial propagation was not tried in this connection, although a supply of eggs was taken to Eastport and their development carefully studied in the laboratory.

On the 13th of November, 1877, Mr. Vinal N. Edwards, an employé of the Fish Commission, while at Noman's Land, engaged in studying the natural history of the spawning cod, took the occasion to artificially impregnate a number of eggs of the sea herring and hatch them out in a floating hatching-box. These eggs hatched in eleven days, the young emerging on the 24th of November. He found the yolk-bag much more sessile than that of the shad. Where the eggs were in clusters they did not ripen, only when placed singly on sea-weed. Kelp seemed to be the best medium for their development.

Experiments were also made in 1877 by Dr. H. A. Meyer, of Kiel, on this same subject, and the results published by him in a Circular of the Deutsche Fisherei-Verein.

To make a success of the artificial impregnation of the herring it will be necessary to adopt some treatment quite different from that with the salmon and shad, and it is doubtful whether the work can ever be done on the same wholesale scale and with the same economy. Probably the best method will be to drop the eggs on glass plates or sheets of wire gauze, the former being preferable on account of the greater facility of keeping the eggs clean.

The specific gravity of the eggs of the herring, which sink to the bottom, is evidently much greater than that of the eggs of the mackerel or cod, which it is well known float persistently at the top. For a judicious

prosecution of the work of hatching various species of fish it will be very desirable to have careful experiments instituted beforehand on this subject. It is well known that the eggs of the shad, trout, and salmon are heavier than fresh water, as their tendency is to sink to the bottom of the vessels in which they are kept. Their specific gravity is probably quite constant in the same species, although possibly differing somewhat in the different stages of development.

Mr. Milner has furnished a memorandum to the effect that in five lots of eggs of the California salmon, tested on the 29th of January, 1878, and some of them well impregnated, the specific gravity varied from 1.07 to 1.09, two samples giving the first figure and three the second. He found that in brook trout treated on the same day, among which a few were hatching prematurely, the density of the two lots varied from 1.156 to 1.159, showing a very appreciably greater density in the latter. I would commend to persons who have facilities for making similar investigations, to determine the difference between the density of the unimpregnated egg, the freshly impregnated egg, and the same series of eggs at different stages of growth, including that of the recently hatched embryo.

The European Turbot and Sole (*Rhombus maximus* and *Solea vulgaris*).

It is a well-established fact that the United States, in the abundance and variety of first-class food-fishes is greatly in advance of any single country in Europe, even of Great Britain, since, while possessing the various species of the cod family, the halibut, mackerel, herring, &c., in common with them, America can show the Spanish mackerel, the pompano, the channel bass, the weak-fish, and many other species of eatable qualities. Any assertion of this superiority on the part of the United States is met by the assurance that in the lack of the turbot and sole, America is without the two finest of all species. There is no question as to the excellence of these fish, especially of the sole, although in the new Pole or Craig flounder, a deep-sea fish discovered by the United States Fish Commission in such enormous abundance off the coast of Massachusetts in 1877, we have what will measurably replace the turbot; and several of our species of flat fish are scarcely, if at all, inferior to the sole.

The importance of having these two European species in our own waters has, however, been suggested to the United States Fish Commission, and it was concluded to take such steps as might be possible to obtain them. Among the gentlemen particularly interested in this transfer was Mr. J. G. Kidder, of Boston, who kindly offered his services with the Cunard Steamship Line from Boston to secure free passage for the fish and their attendant from Liverpool to Boston. He accordingly obtained letters from the agent of the line at Boston to the directors in Liverpool which accomplished their desired object.

Reference has already been made to the agency of Mr. Fred Mather

in the transportation of California salmon to Europe. That gentleman was instructed to proceed to Liverpool and obtain a supply of the turbot and sole, suitable for transfer, to be brought back to Boston on the Cunard steamer, with such facilities as he could obtain on that occasion. A correspondence had been entered upon some time before with Mr. F. Moore, the accomplished curator of the Free Public Museum of Liverpool, who made many inquiries as to the proper localities and the best mode of obtaining these fish.

Mr. Mather reached Liverpool on the 17th of November, and, reporting himself to Mr. Moore, found that gentleman had invoked the assistance of the authorities of the great aquarium of Southport. Proceeding to this place, Mr. Mather was received very cordially by Mr. John Long, the superintendent of the aquarium; but owing to the inclemency of the weather it was impossible to obtain any number of fish, and in order to have a proper supply it was necessary to secure the further services of some of the fishermen. Unfortunately the weather, after Mr. Mather's arrival, proved to be exceptionally stormy, and the few fish obtained were so badly bruised that they died shortly after being introduced into the tanks of the Southport aquarium. There was some question in regard to Mr. Mather's free passage in the shipment of the fish, and it was not until the 3d of January that the shipment was actually made. This consisted of six turbot and twenty-six soles, the vessel upon which they were placed being the Siberia, of the Cunard line, Captain McKay commanding. Mr. Mather, with his precious charge, experienced a series of accidents on the voyage homeward. In the first place the tanks were found to have been placed in such proximity to the steam heating pipes that the water soon rose to a temperature of 72°, much higher than is suited to this fish. On arriving within sight of Cape Cod, on the 16th of January, only two soles survived, and after consultation with the captain as to a suitable place of deposit, it was concluded to place them overboard, and they were accordingly left at a point on the Stelwagen Bank, two miles off Nahant, in 18 fathoms of water, the surface temperature be ng 31°.

It is hoped that, as in the case of the shipment of California salmon, the experience thus gained will enable us to avoid a failure on another occasion. Mr. Mather is of the opinion that by keeping the temperature at as low a degree as possible one of the most serious dangers may be avoided. He does not recommend anything in the way of gravel or sand in the tanks, as the fish would be liable to abrasion, in the motion of the vessel. He also recommends that the fish, before such transportation, should be kept in captivity and fed for at least one month, as this will show whether the act of capturing has in any way injured the fish.

Anticipating the occasion of taking these fish from the wharf at Boston for deposit at some suitable point in the harbor, application was made to the Treasury Department for the service of the revenue-cutter,

and instructions were given to the collector of customs at Boston, Mr. C. B. Simmons, to supply this and such facilities as were required. Every assurance was received from Mr. Simmons of his willingness to co-operate; and the steamer, the revenue-cutter Grant, was in readiness on the arrival of the English steamer; but, as it proved, the deposit of the two surviving fish had already been made.

It is, of course, impossible to tell whether from a single pair of fish any yield may be expected. The fact is, however, now one of record, that soles have been actually transported and introduced into American waters. Mr. Mather's account of his experiences on this trip will be found in the Appendix.

APPENDIX A.

THE SEA FISHERIES.

(A HISTORY OF THE MENHADEN.)

I

TABLE OF CONTENTS.

I.—THE NATURAL AND ECONOMICAL HISTORY OF THE AMERICAN MENHADEN.

BY G. BROWN GOODE.

A—INTRODUCTION.

1.—OBJECT OF THE MEMOIR.

Previous memoirs in this series.

1. In the first report of the Commissioner of Fish and Fisheries,* was commenced the publication of a series of memoirs upon the important fishes of the United States. Professor Baird inaugurated the work with two treatises from his own pen with the following titles:

I. THE SCUP. *Stenotomus argyrops*, (Linn.) Gill.†

II. THE BLUEFISH. *Pomatomus saltatrix*, (Linn.) Gill.‡

The present memoir is the third of this series. The work of preparing it was assigned to me in September, 1874. I have tried to make it exhaustive, including everything known about the subject, and statistics up to January 1, 1878. There are still, however, many questions which need further study, for the subject is not at all well understood. I send the manuscript to the printer with reluctance, hoping at some time to resume the study of the many unsolved problems.

The commercial importance of the menhaden.

2. The menhaden has grown greatly in favor within a comparatively short time. Twenty-five years ago, and before, it was thought to be of very small value. A few millions were taken every year in Massachusetts Bay, Long Island Sound, and the bays of New Jersey. A small portion of these were used for bait; a few barrels were occasionally salted in Massachusetts to be exported to the West Indies. Large quantities were plowed into the soil of the farms along the shores, stimulating the crops for a time, but in the end filling the soil with oil, parching it, and making it unfit for tillage. Since that time manifold uses have been discovered. As a bait-fish, this is found to excel all others. For many years much the greater share of all our mackerel have been caught by its aid, while our cod and halibut fleet use it, rather than

* United States Commission of Fish and Fisheries. | —— | Part 1. | —— | Report | on the | Condition of the Sea Fisheries | of the | South Coast of New England | in | 1871 and 1872. | By | Spencer F. Baird, | Commissioner. | —— | With supplementary papers. | —— | Washington: | Government Printing Office. | 1873. 8vo., pp. xlvii, 852, 40 plates, 2 maps.

† Op. cit., pp. 228–235.

‡ Op. cit., pp. 235–252.

any other fish, when it can be procured. The Dominion mackerel fleet buy it in quantity, and its value has been thought an important element in framing treaties between our government and that of Great Britain. As a food resource it is found to have great possibilities. Many hundreds of barrels are sold, salted, in the West Indies, while thousands of barrels are salted down every year for domestic use by families living near the shore. In many sections the fresh fish are sold in the market. Within five years has sprung up an important new industry, which consists in packing these fish in oil, after the manner of sardines, for home and foreign consumption. The discovery made by Mr. Goodale, that from these fish may be extracted, for the cost of carefully boiling them, a substance possessing all the properties of Liebig's "extract of beef," opens up a vast field for future development. As a food for domestic animals, in the shape of "fish meal," there seems also to be a broad opening. As a source of oil the menhaden is more important than any other marine animal: its annual yield usually exceeds that of the whale (from American fisheries) by about 200,000 gallons, in 1874 not falling far short of the aggregate of all the whale, seal, and cod oil made in America. The refuse of the oil-factories supplies a material of much value for manures: as a base for nitrogen it enters largely into the composition of most of the manufactured fertilizers. The amount of "ammonia" derived from this source in 1875 was estimated to be equivalent to that contained in 60,000,000 pounds of guano from Peru, the gold value of which would not be far from $1,920,000. In 1876 the yield of the menhaden fishery was more than twice that of any other carried on by the fishermen of the United States. In the value of its products it was surpassed only by the cod and mackerel fisheries.*

Imperfect information regarding the species.

3. At the time of beginning the investigation, the results of which are partially detailed in this memoir, comparatively little was known about the menhaden. The species had been described or referred to in most of the books on the ichthyology of North America, and in

* The following table of estimates shows in a general way the relative values of the fisheries in 1876:

Fisheries.	Yield in pounds.	Value.
Menhaden fishery	462, 000, 000	$1, 657, 790
Cod fishery	215, 000, 000	4, 825, 540
Mackerel fishery	49, 000, 000	2, 375, 262
Fisheries of the great lakes (1872)	32, 250, 000	1, 600, 000
Salmon fishery of Columbia River	30, 000, 000	2, 500, 000
Halibut fishery	22, 000, 000	1, 546, 240
Shad fishery (estimate)	20, 000, 000	1, 000, 000
Scup fishery	7, 760, 000	504, 400
Bluefish fishery	7, 068, 000	424, 000
Swordfish fishery	1, 500, 000	165, 000
Bonito fishery	2, 200, 000	143, 000
Squeteague fishery	1, 800, 000	138, 200
Flounders fishery	1, 827, 000	109, 620
Herring fishery (partly in British waters)	27, 933, 500	507, 977
Whale fishery		2, 850, 000
Oyster fishery		25, 000, 000

some of the general ichthyological treatises. Mitchill, Storer, and Dekay had given imperfect figures. Allusions were made to its economical value by some of the books mentioned, and in agricultural and statistical works occasional reference had been made to its importance as a manure. Up to the present day the reports of the Commissioner of Agriculture have barely referred to the existence of this source of fertilizing material. Many persons engaged in fishing or manufacturing had a comprehensive knowledge of some parts of its history, but these had never been written or printed. There was no adequate account of this fish accessible to the student. Recognizing the necessity of supplying this need, the Commissioner of Fisheries chose this species as the next to be studied.

2.—Means used to gather information.

4. A circular was issued, December 20, 1873, requesting information upon many points in the history of the menhaden, and propounding fifty-eight questions for the guidance of those disposed to aid in the investigation.* This was distributed to manufacturers, fishermen, and all known to be interested in the fisheries. Through the courtesy of the Secretary of the Treasury and the Chairman of the Light-House Board it was also sent to all collectors of customs and light-house keepers on the Atlantic and Gulf of Mexico. A second edition of this circular was issued in 1874.

5. Personal letters have been addressed to nearly all the intelligent respondents to the circular, and to many others, asking information upon uncertain points.

6. The attention of the marine branch of the Fish Commission has for four seasons been especially directed to the menhaden, especially with a view to learning about its food and its habits of spawning.

3.—Sources of information.

7. At the beginning of this work Professor Baird gave me five or six pages of closely-written manuscript containing his own observations made during five or six summers on the coast of New England. These have been of the greatest importance, and my own work has been little more than that of expanding and carrying out the suggestions there made. I have also made use of notes made by Professors Smith and Verrill, and by Mr. Vinal N. Edwards, and the testimony taken by Professor Baird, in 1872.

Personal observations and aid of individuals.

8. While with the Commission at Eastport, Me., in 1872; Portland, Me., in 1873; at Noank, Conn., in 1874; at Wood's Holl, Mass., in 1875; and at Salem, Mass., and Halifax, Nova Scotia, in 1877, I used every opportunity to study this fish. I have also had opportunities of observing it at the mouth of the Saint John's River, Florida; in the Potomac, at sev-

* This circular is reproduced in Appendix A.

eral of the fisheries; at Greenport, N. Y., and Provincetown, Mass. In October, 1877, I visited Mr. H. L. Dudley, at his works on Pine Island, Connecticut, and there had an excellent opportunity of observing the operations of an oil and guano factory. A similar opportunity was afforded me by the officers of the Pacific Guano Company at Wood's Holl. Here I was enabled, by the aid of Mr. Herbert Gill, stenographer, to obtain very full statistics.

In addition to the circulars, over two hundred personal letters have been written. In almost every case full and satisfactory replies were received. The following gentlemen have been particularly obliging:—

Mr. H. L. Dudley, Secretary of United States Menhaden Oil and Guano Association, New Haven, Conn.; Mr. D. T. Church, Tiverton, R. I.; Prof. C. A. Goessman, Massachusetts Agricultural College, Amherst, Mass.; Mr. E. H. Jenkins, Connecticut Agricultural Experiment Station, New Haven, Conn.; Hon. S. L. Goodale, Saco, Me.; Mr. E. G. Blackford, New York City; Mr. Barnet Phillips, New York City; Mr. W. O. Allison and Mr. Jasper Pryer, New York City.

I am also under obligation to Prof. W. O. Atwater, of Wesleyan University, who has written the portion relating to agriculture; to Mr. H. L. Dudley, for advice and criticism; and to Mr. Herbert A. Gill of the Smithsonian Institution, Mr. William Jameson, and Mr. Walter P. Stoddard, of Wesleyan University, for aid in preparing the manuscripts for the press. My associate, Dr. T. H. Bean, has worked with me in studying the specific characters of the two species of *Brevoortia*. The drawings are by Mr. J. H. Emerton, of Salem, and Mr. H. L. Todd, of Washington. Electrotypes have been obtained from the "American Agriculturist," from George W. Miles & Co., the American Sardine Company, and the Pacific Guano Company.

Responses to the circular of inquiry.

9. The circular of inquiry elicited responses from the correspondents named below, in Appendix B, most of which were carefully prepared, and in many cases give the results of years of observation. In Appendix N will be found these responses in full.

Published accounts of the species.

10. In discussing the history of the name and classification of the *Brevoortia tyrannus* and its allies, allusion is made to various books, and so incidentally under other heads. In Appendix C will be found a complete bibliography of the subject, containing about one hundred and forty citations. Many of these authorities have been quoted in the text. Some of the most important descriptions have been reproduced in Appendix D.

Most of the work on this report was done in the winter of 1874–'75. Since that time two pamphlets have been published, containing very valuable contributions to the knowledge of the menhaden. From these

I have derived much information and have quoted freely. The first was the report of Messrs. Boardman and Atkins.* The most recent contribution is that prepared by Mr. Luther Maddocks, under the auspices of the Maine association.† This is a most interesting little essay, especially valuable for the complete statistics of fisheries and manufactures in Maine, and the account of the relations of the fisheries to the fishermen, the shore population, and the property of the adjoining towns.

The collections of the United States National Museum.

11. The collections of the Fish Commission, deposited in the National Museum, contain over one hundred bottles of menhaden in alcohol, including probably over one thousand specimens, from many localities, with photographs and casts. A list of these is given in Appendix E.

There is also a model of the menhaden fishing steamer "Leonard Brightman" with seine-boats (No. 25824, Ethn. Cat.), made by Joseph Lawler, of Bristol, Me.; models of the Cape Ann seine-boat (No. 25800), with fittings, and the Cape Ann seining-dory (No. 25827), from Higgins and Gifford, of Gloucester; a full series of "fittings" for seine-boats, manufactured by Wilcox and Crittenden, of Middletown, Conn., including "cleats" (No. 25177), "steering rowlocks with stern-sockets" (Nos. 25113–'14), "oar-holders" of old and new models (Nos. 25171–'72), "davit-iron" (No. 25166), "tow-iron" (No. 25167), and "tow link and hook" (No. 25168); a pump box and haft for seine-boat (No. 29499) from Andrew Kennedy, of Provincetown. The Pacific Guano Company is represented by a large model of their works, the same which was exhibited in their pavilion at the Exposition grounds in Philadelphia, and there is a very satisfactory model of the oil factory of Joseph Church & Co., at Bristol, Me. (No. 26899), made by Joseph Lawler.

4.—Sources of error which have been shunned.

The difficulty of obtaining exact information.

12. It has been necessary to make allowances for many inaccuracies of statement on the part of our correspondents. Some of them, having

* The | Menhaden and Herring Fisheries | of Maine | as sources of fertilization. | A Report made to the Maine Board of Agriculture | By Samuel L. Boardman, Secretary of the Board | and | Charles G. Atkins, formerly Fish Commissioner of Maine, | 8vo. 1875, pp. 67.

Under direction of the Maine Board of Agriculture, Mr. Samuel L. Boardman, its secretary, visited in 1874 and 1875 nearly all the manufacturing establishments in Maine, thoroughly investigating their operations. The account of the agricultural uses of fish is the most complete which has yet been published (pp. 34–67). Mr. Charles G. Atkins, formerly commissioner of fisheries for the State of Maine, and for several years in charge of the salmon-hatching establishment at Bucksport, contributed a very thorough study of the habits of the fish (pp. 1–33).

† The Menhaden fishery of Maine | with statistical and historical details | its | relations to Agriculture | and as a | direct source of human food | —— | New processes, products, and discoveries | —— | Published by the | Association of the Menhaden Oil and Guano Manufacturers of Maine | Press of B. Thurston & Company, Portland, 1878. 8vo. p. 46, 4 cuts.

been unable to obtain exact information, have ventured to guess at what they did not really know from experience. I do not think that there has been intentional misrepresentation or any effort to withhold information. There being no ulterior object, such as future legislation, in collecting this information, there has been no temptation to concealment; still the testimony has been partly that of interested persons. The most fair and honorable men, however careful may be their observations, are involuntarily influenced by preconceived opinions or by considerations of personal interest, and, even if it were possible to secure unprejudiced opinions, these necessarily would express only part of the truth. Then, too, the movements of fishes are so capricious, the opportunities of observation so few and so imperfect, that satisfactory results can, in most cases, be reached only after years of constant study.

Prejudices and superstitions.

13. Some curious prejudices and fancies have been encountered among the fishermen. These refer chiefly to the time and manner of spawning, the character of the eggs, the nature of their food, and the relation of the fish to its peculiar parasite.

Inaccuracies of observation and statement.

14. There has been some difficulty in eliminating unreliable data from the great mass of facts contributed by correspondents. This, however, has not been so great as was apprehended at the beginning of the work, since a knowledge of the beliefs and traditions current among seafaring men renders it easy to detect many of the errors at once. The concurrent testimony of a number of reliable correspondents has been thought sufficient to establish points in question: when possible, these have been investigated personally, to render their establishment doubly certain. A large proportion of the communications received have evidently been prepared with much care. It is believed that many facts hitherto unrecorded have been brought to light by this investigation. All communications are given in full in Appendix N. This has been done both to show the character of the testimony upon which this history has been founded, and to put upon record many facts which, while not directly connected with the subject under consideration, are nevertheless of value to the student of the fisheries.

B.—THE NAMES OF THE MENHADEN.

5.—POPULAR NAMES.

Local names and usages.

15. *Brevoortia tyrannus* has at least thirty distinct popular names, most of them limited in application within narrow geographical boundaries. To this circumstance may be attributed the prevailing ignorance regard-

ing its habits and migrations, which has perhaps prevented the more extensive utilization of this fish, particularly in the Southern States. It accounts for the extraordinary blunder of the compilers of the fishery statistics of the census of the United States for 1870, in which the oils produced from the whitefish of the great lakes (*Coregonus albus*) and the whitefish of Connecticut are classed as identical, a blunder which is followed by a number of others of the same character and quite as certain to mislead. The discrepancy of local names also enables us to understand how the extensive manufacturing interests and fisheries connected with this fish have gradually sprung up, little noticed save by those directly interested in the business.

The geographical distribution of the popular names.

16. In Maine and Massachusetts the name "pogy" is almost universally in use, though in the vicinity of Cape Ann it is partially replaced by "hard-head" and "hard-head shad." The name "menhaden" is exclusively applied in Southern Massachusetts, the Vineyard Sound, Buzzard's Bay, and Narragansett Bay, where it appears to have originated. From the eastern boundary of Connecticut to the mouth of the Connecticut River the name "bony-fish" predominates, while in the western part of the State the species is usually known as the "white fish." In the waters of New York the usage of two centuries is in favor of "mossbunker," a name which also holds throughout New Jersey. In Delaware Bay, the Potomac, and Chesapeake Bay other variations are found in "alewife" and "greentail." Virginia gives us "bug-fish" in its various forms, while in North Carolina we first meet the name of "fat-back," which is more or less prevalent as far south as the Saint John's River, Florida. In all the Southern States, especially in the vicinity of Beaufort, N. C., the names "yellow-tail" and "yellow-tailed shad" are occasionally heard. I am informed that in the Indian River, Florida, the fish is occasionally called the "shiner" and the "herring."

17. The following table gives the usage at a number of points on the coast chosen to exhibit most clearly the geographical distribution of the popular names of *Brevoortia tyrannus:*

Passamaquoddy Bay, Me	Pogy; Bony-fish.
Castine, Me	Pogy; Menhaden.
Belfast, Me	Pogy.
Brooklin, Me	Pogy.
Cranberry Isles, Me	Pogy.
Sargentsville, Me	Pogy.
Matinicus Rock, Me	Pogy; Porgie; Menhaden.
New Harbor, Me	Menhaden.
Manhegin Island, Me	Pogy.
Damariscotta, Me	Pogy; Mossbunker.
Pemaquid, Me	Pogy; Menhaden.

Muscongus, Me	Pogy; Menhaden.
Boothbay, Me	Pogy; Menhaden.
Bristol, Me	Pogy; Menhaden.
Round Pond, Me	Pogy.
Waldoboro', Me	Pogy.
Pond Island, Me	Pogy; Menhaden.
Portland, Me	Pogy.
Pine Point, Me	Pogy.
Portsmouth, N. H	Pogy.
Rockport, Mass	Pogy; Menhaden.
Gloucester, Mass	Pogy; Porgie; Menhaden; Hardhead
Salem, Mass	Pogy; Hardhead.
Marblehead, Mass	Hardhead; Pogy; Menhaden.
Swampscott, Mass	Pogy; Menhaden.
Plymouth, Mass	Pogy; Menhaden.
Wellfleet, Mass	Pogy; Hardhead.
Truro, Mass	Pogy.
Provincetown, Mass	Pogy; Menhaden.
Chatham, Mass	Pogy; Menhaden.
Hyannis, Mass	Pogy; Menhaden.
Nantucket, Mass	Pogy; Poggie; Menhaden.
Edgartown, Mass	Menhaden.
North Tisbury, Mass	Menhaden.
Woods Holl, Mass	Menhaden.
New Bedford, Mass	Menhaden.
Tiverton, R. I	Menhaden.
Newport, R. I	Menhaden; Mossbunker.
New Shoreham, R. I., (Block Isl'd)	Menhaden.
Point Judith, R. I	Menhaden.
Watch Hill, R. I	Bony-fish.
Stonington, Conn	Bony-fish.
Mystic, Conn	Bony-fish.
Noank, Conn	Bony-fish.
New London, Conn	Bony-fish.
Groton, Conn	Bony-fish.
Lyme, Conn	Bony-fish.
Saybrook, Conn	Bony-fish; White-fish
Westbrook, Conn	White-fish.
Guilford, Conn	White-fish.
New Haven, Conn	White-fish; Menhaden.
Milford, Conn	White-fish; Menhaden.
Stratford, Conn	White-fish; Menhaden; Bunker.
Bridgeport, Conn	White-fish.
Norwalk, Conn	White-fish.
Montauk Point, N. Y	Bony-fish.
Napeague, N. Y	Bony-fish.

Jamesport, N. Y	Mossbunker; Menhaden.
Sag Harbor, N. Y	Mossbunker.
New York City and vicinity	Mossbunker.
Port Monmouth, N. J	Mossbunker.
Tuckerton, N. J	Mossbunker.
Atlantic City, N. J	Mossbunker.
Somers Point, N. J	Mossbunker.
Cape May, N. J	Bony-fish.
Bombay Hook, Del	Mossbunker; Oldwife; Bug-fish.
Mispillion River, Delaware	Old-wife.
Maurice River	Mossbunker; Old-wife Chebog.
Hog Island	Mossbunker; Ell-wife.
Tangier Sound, Maryland	Alewife.
Pocomoke Sound, Maryland	Alewife.
Marlboro', Md	Alewife.
Nanjemoy, Md	Alewife.
Point Lookout	Alewife.
Apateague Island, Va	Alewife.
Washington, D. C	Alewife; Bug-fish.
Potomac River	Alewife; Bug-fish; Greentail.
York River, Va	Alewife; Bug-head.
Rappahannock River, Virginia	Old-wife; Wife; Bug-head.
Cape Henry, Virginia	Alewife; Bony-fish.
Edenton, N. C	Bug-fish.
Cape Hatteras	Fat-back; Menhaden.
Beaufort, N. C	Fat-back; Yellow-tail shad.
Body's Island, N. C	Fat-back.
Fort Macon, N. C	Fat-back.
Charleston, S. C	Menhaden; Mossbunker.
Saint Mary's, Ga	Menhaden.
Saint John's River, Florida	Menhaden; Mossbunker; Fat-back.

Discrepancies in the popular names.

18. These names are not separated in their distribution by sharply-defined boundaries. Still, as a glance at the table will show, the *habitat*, if that term may be legitimately used, of each local appellation appears to be clearly marked. Where there is a discrepancy it can usually be explained. For instance, the general use of the name "menhaden" in the vicinity of Boothbay, Me., is due to the presence of a large number of fishermen and laborers from Rhode Island who carry on the oil-factories in that region. In the same way the name "bony-fish" has been naturalized at Montauk Point and Napeague, N. Y. The factories in that neighborhood are owned by firms in Eastern Connecticut, and the Connecticut "bony-fish fleet" has a favorite cruising ground in the waters of Eastern Long Island. The names "menhaden" and "mossbunker" have been introduced into Florida by northern fishermen, who

prosecute the winter shad fisheries on the Saint John's, and these same names are more or less familiar all along the coast wherever the northern coasters and fishing vessels are known.

The name preferable for adoption.

19. The adoption of some one suitable name for popular use is eminently desirable. "Menhaden" is the name most generally known, as well as the most distinctive. It has the additional recommendation of having been derived from an aboriginal language. It has been used in the titles of the two manufacturers' associations, and it is hoped that this usage will soon be conformed to by all.

Trade-names.

20. Among the manufacturers in Port Monmouth, N. J., who prepare the menhaden as an article of food, a number of trade-names are in use, such as "American sardine" (in distinction from the European fish, which is prepared in a similar manner), "shadine," and "ocean trout." *

Etymologies.

21. A few words concerning the origin of the above-mentioned names may not be out of place. "Pogy" and "menhaden" are derived somewhat remotely from the Indian dialects of New England, the latter apparently from that in use in Massachusetts and Rhode Island, the former from a more northern source. The writer is indebted to Prof. J. Hammond Trumbull, of Hartford, Conn., for the following very suggestive letter:

---

* This fanciful name has been the occasion of many erroneous statements. In the New York Times for April 12, 1874, appeared an article entitled "American Sardines," which contained the following bit of biography: "The fish selected as the substitute for the sardine of Europe is the menhaden, more commonly known as the moss-bunker, and the scientific name of which is *Trutta Oceana*, or ocean-trout. Its color is silver, spotted with dark brown, and in the night-time assumes a reddish or fiery tinge. They abound in the seas east of the Canadas and in the bays and deep rivers which indent the New Brunswick, Newfoundland, and Nova Scotia coasts, and from which they migrate in the spring of the year to the southward, and appear in great shoals along the coast of Long Island and in the Raritan and Lower New York bays. A mile or two to the northward of Sandy Hook is their favorite feeding-ground for the spring and summer, and thither they rendezvous toward the close of April in vast schools, numbering millions. They invariably come on with the warm weather, and remain until fall. Their breeding time is late in the winter," &c. These ridiculous statements, evidently compiled in part from printed accounts of the sea-trout (*Salmo immaculatus*, Storer) of the North, partly from the statements of the menhaden fishermen, but principally from the imagination of the writer, would perhaps not be worthy of notice had they not been copied by the European newspapers. A translation, with emendations which make it still more absurd, appeared in *Das Ausland* for August 17, 1874. The Stuttgart paper emends its name to *Trutta trutta*, and states that it resembles in color the brook-trout to which it is very closely allied.

"HARTFORD, CONN., *Dec.* 19, 1874.

"MR. G. BROWN GOODE:

"MY DEAR SIR: In reply to yours of the 14th respecting the local names of the *Brevoortia menhaden*, about all I can give you is in my note to the new edition of Roger Williams' Key, ch. xix. Williams names, together, among spring fish, "*Aumsûog* and *Munnawhatteaûg*." Under the former name are included several species of the herring tribe, *aum'su* (plural, *aums'uog*) meaning 'small fish.' *Munnawhatteaûg*, corrupted to *Menhaden*, means, literally 'fertilizer' ('that which *manures*.') This name was applied to the herring and alewife as well as the 'menhaden' proper,—all these species being used by the Indians for manuring their cornfields.

"In the northern and eastern parts of New England the *Brevoortia* is commonly called *Pauhagen*, and probably in some localities 'poghaden' (as you write it and which is nearer the Indian original) though I have not heard it so pronounced by eastern fishermen. This name in the eastern dialects has precisely the same meaning as 'menhaden' (or rather *munnawhatteaûg* in Southern New England). The Abnaki (*i. e.*, coast of Maine) name was *Pookagan* as Rasles wrote it, and the verb from which it is derived he translated by 'on engraisse la terre.'

"*Mossbunker* is classic. Dr. Bartlett in his Dictionary of Americanisms quotes from Dow, jr.'s Sermons a remark that 'under the surface [of some smooth faced people] there may be found as many asperities as there are bones in a *mossbunker*.'

"Jacob Steendam mentions it in his poem 'in the Praise of New Netherland,' printed in 1661. Dankers and Sluyter, the Journal of whose Voyage to New York, 1679, was translated by Mr. Murphy for the L. I. Historical Society's Collection, vol. i. (p. 100), saw in the bay schools of innumerable fish, and a sort like herring called there '*Marsbanckers*.'

"I have never looked for the origin of this name, but have had the impression that it was Dutch, perhaps transferred from some European species. I can make nothing of it as Indian.

"Yours truly,

"J. HAMMOND TRUMBULL."

22. According to Mr. J. V. C. Smith,* the older fishermen of Northern Massachusetts, New Hampshire, and Maine called the fish by the Indian name "Pauhagen," and I myself have heard it called "poghaden" by old fishermen about Cape Cod. The modern name may easily have been derived from this by dropping the final syllable. At the present day this name is almost universally in use among the fishermen north of Cape Cod, though it is occasionally varied by "poggie" and "porgy." The use of the latter name should be carefully avoided: the same name, a corruption of the Indian "scuppaug," being commonly applied to

* Natural History of the Fishes of Massachusetts, embracing a practical essay on angling. By Jerome V. C. Smith, M. D., Boston. Allen and Ticknor, 1833.

another fish, the "scuppaug" or "scup" (*Stenotomus argyrops.*)* As may be supposed, the name of Narragansett origin is most exclusively used in Southern Massachusetts and on the shores of Narragansett Bay, the former home of that tribe of Indians. In its present form it first appeared in print in 1792, in the New York Agricultural Transactions, in an article by the Hon. Ezra L'Hommedieu.†

23. "Hard-head" and "bony-fish" explain themselves, both referring to the same peculiarity of structure. The former name was first used about 1813 by Belknap in his History of New Hampshire; the latter, as well as "white-fish," by President Dwight in his Travels in New England.

24. The application of "white-fish" is also sufficiently evident, although this name is not a distinctive one, being applied to a large group of North American fresh-water fishes, the *Coregonidæ*, and in certain localities to the bluefish (*Pomatomus saltatrix*). In England the term "white-fish" is used to designate cod, haddock, hake, ling, pollock, soles, turbot, plaice, halibut, and whiting

25. "Mossbunker" is a relic of the days of the Dutch colony at New Amsterdam, and the name is still lovingly retained by the inhabitants of Manhattan Island. It was in use as early as 1661, as we learn from an allusion in Jacob Steendam's poem in "Praise of New Netherland" (*'t Louf van Niew Nederland*).‡

The allusion to the Mossbunker is as follows:

> " Swart-vis, en Roch, en Haring, en Makreel
> Schelvis, Masbank, en Voren die (se veel)
> Tot walgins toe, de netten'vuld: en heel
> Min ward ge-eeten."
>
> " The black and rock-fish, herring, mackerel,
> The haddock, mossbanker, and roach, which fill
> The nets to loathing; and so many, all
> Cannot be eaten."

Allusion has already been made in the letter of Professor Trumbull, to the great schools of "marsbanckers" seen by Dankers and Sluyter on their visit to New York, in 1679, and every one remembers the reference to this fish in Irving's "Knickerbocker," in connection with the death of the renowned trumpeter, Antony Van Corlear, where the name first appears crystallized in its present form.§

* This probably misled De Kay, who stated that the menhaden were known at the eastern end of Long Island as "skippaugs." He also remarked that "pauhagen" (pronounced *Pauhaugen*) was the Narragansett epithet, while "*menhaden*" was that applied by the Manhattan Indians.

† Appendix O.

‡ This poem, cited by Professor Trumbull in the Report of the Commission of Fish and Fisheries for 1871–'72, p. 168, was printed, with an English translation, by Hon. Henry C. Murphy, for the Bradford Club, of New York (Anthology of New Netherland: Bradford Club Series, No. 4, 1865, pp. 52, 55).

§ A History of New York * * * By Diedrich Knickerbocker. New York, 1809.

"It was a dark and stormy night when the good Antony arrived at the creek (sagely denominated Haerlem *river*) which separates the island of Mannahatta from the main

The derivation of this name may be easily traced, it having evidently been transferred by the Dutch colonists from the scad or horse-mackerel, *Caranx trachurus* (Linn.) Lacepede, a fish which annually visits the shores of Northern Europe in immense schools, swimming at the surface in much the same manner as our *Brevoortia*, and which is known to the Hollanders as the *Marsbanker*.*

In the Museum Ichthyologicum of Gronow,† published in 1754, the name *Marsbanker* is used in speaking of a scombroid fish, frequently taken with the herring, probably the same below referred to.‡

The name is variously spelled "mossbunker," "mossbonker," "massbanker," "mousebunker," "marshbunker," "marshbanker," and "morsebonker," and is also familiarly shortened into "bunker," a name in common use at the eastern end of Long Island.

26. The name "alewife" was given by the Virginia colonists to this species from its resemblance to the allied species known by that name in England. This name is preoccupied by the *Pomolobus pseudoharengus*, and should never be applied to *Brevoortia*.

27. The presence of a parasitic crustacean (*Cymothoa prægustator*) in the mouth of *Brevoortia*, when found in southern waters, explains the name "bug-fish" prevalent in Delaware and Cheaspeake Bays, the Potomac and Rappahannock Rivers, and the inlets of North Carolina, with its local variations of "bug-head" and "buggy-head."§ "Yellow-

---

land. The wind was high, the elements in an uproar, and no Charon could be found to ferry the adventurous sounder of brass across the water. For a short time he vapored like an impatient ghost upon the brink and then, bethinking himself of the urgency of his errand, took a hearty embrace of his stone bottle, swore most valorously that he would swim across in spite of the devil (Spyt den Duyvel), and daringly plunged into the chasm. * * * An old Dutch burgher, famed for his veracity, and who had been a witness of the fact, related to them * * * that he saw the duyvel, in the shape of a huge moss-bonker, seize the sturdy Antony by the leg and drag him beneath the waves. * * * Nobody ever attempts to swim across the creek after dark, and as to the moss-bonkers, they are held in such abhorrence that no good Dutchman will admit them to his table who loves good fish and hates the devil."

* See Schlegel, Die Dieren van Nederland, Visschen, p. 4.

† Museum | Ichthyologicum, | sistens | Piscium | indigenorum & quorundam exoticorum, | qui in | Museo | Lawrentii Theodori | Gronovii, J. U. D. | adservantur, descriptiones | ordine systematico. | Accedunt | nonnullorum exoticorum Piscium icones æri incisæ. | * * * * * | (Cut) | Lugduni Batavorum, | Apud Theodorum Haak, | MDCCLIV. | folio, 10 preliminary pages, pp. 70.

‡ 80. *Scomber* linea laterali aculeata, pinna ani ossiculorum triginta, *Arted. Gen.* 25, n. 3, *Synon.* p. 50, n. 3.

Scomber linea laterali curva, tabellis osseis loricata, *Gronov. act. ups.* 1742, p. 83, ibique defer. Trachurus, *Bossuet*, epigr. p. 74, *Bellon. Aquat.* p. 180, *Dale.* Hist. of Harw., p. 131, n. 5.

Belgis *Marsbanker* Frequentissime in Mari Septentrionale cum Clupeis p. 5, n. 4, descriptis capitur.

Op. cit. p. 34.

§ Captain Atwood states in the Proceedings of the Boston Society of Natural History, x, 1865, p. 67, that the half-grown menhaden are called "bug-fish" by the Virginia negroes, because they believe them to have been produced from insects, since they never find spawn in them there.

tail," "yellow-tailed shad," and "green-tail" refer to the yellowish-green tint of the caudal fin, observed only in Southern specimens. The former of these names has led to some confusion among our correspondents, the same name being applied in Georgia and Florida to a very different fish, *Bairdiella punctata* (Linn.) Gill.

28. An allusion to the oily nature of the flesh is found in "fat-back," a name in general use in the Southern States. This name is sometimes applied in Northampton County, Virginia, to the mullet (*Mugil lineatus*). In the last century it was used for the *Albula conorhynchus*.*

The conflict of names among the American representatives of the herring family.

29. The representatives of the herring family most abundant in the waters of Great Britain are three—the shad (*Alosa finta*), the alewife (*Alosa vulgaris*), and the herring (*Clupea harengus*). Their names were at an early date appropriated for representatives of the same family on our own coast. The name "shad" is, from Maine to Florida, yielded by common consent to our *Alosa sapidissima*, which, in many particulars, resembles its namesake, though they "be bigger than the English Shaddes and fatter," as an early writer declares.†

In the Southern States this fish is sometimes called "white-shad," to distinguish it from the *Dorosoma Cepedianum*, there known as the "mud-shad" or "gizzard-shad." On the coast of New England, the mattowocca or tailor-herring (*Pomolobus mediocris*) is sometimes called the "hickory-shad," and also the "sea-shad," under which name it is often confounded with the true shad, which is known from recent investigations to be frequently taken far out at sea in company with mackerel, alewives, and menhaden. In the Bermudas, there being no large clupeoid fish, the same name has been for centuries applied to two species which somewhat resemble it externally—*Eucinostomus gula* and *Eucinostomus Lefroyi*, Goode.

The "herring," or "English herring," of New England north of Cape Cod is identical with that of Great Britain, but at certain points in Southern New England, such as New Bedford, this name is transferred to *Pomolobus pseudoharengus*, and on the Hudson River the usage is general, though the species is occasionally called the alewife. South of the Hudson the name "herring" is universally used in connection with this species of *Pomolobus*, and the allied *Pomolobus mediocris* or "mattowocca," which is known as the "tailor-herring" or sometimes, as in the Saint John's River and about Cape Cod, as the "hickory-shad." In the great lakes the name "herring" is also represented, being applied to one of the whitefish family, the lake-herring (*Argyrosomus clupeiformis*).

To *Pomolobus pseudoharengus* the name "alewife" is commonly ap-

* See Garden, in Correspondence of Linnæus, p. 335.

† New England's Prospect. By William Wood. London, 1634.

applied in New England, and even, occasionally, as mentioned above, in New York. South of New York it is used for *Brevoortia tyrannus* only. The name is corrupted into "old-wife" and "ell-wife," "wife," and on the Connecticut River appears under the guise of "ell-whop." At Maurice River the *Brevoortia* is called "old-wife chebog," "chebog" being probably of Indian origin. Thomas Morton, writing in 1632 of the fishes of Virginia, gives the names "shadd" and "allize" as in use among the colonists at that time.* The original derivation of the word "alewife" is somewhat obscure, though it may probably have originated in *Alausa*, the name applied by Ausonius to the European shads in his celebrated poem on the Moselle River—

> Quis non ——— norit,
> Stridentesque focis opsonia plebis alausas.

The transition through the French "alose," the English "allis," "allice," or "alize," is not difficult, and when we find these names together with "alewife" applied indiscriminately to the same fish, it is, to say the least, suggestive. Such an etymology is at least more satisfactory than that of Josselyn, so often quoted: "The Alewife is like a Herrin, but has a bigger bellie; therefore called an Alewife."†

6. ZOOLOGICAL NAMES.

Latrobe's description of Clupea tyrannus.

30. Our species was first described by Mr. B. H. Latrobe, in a communication to the American Philosophical Society in 1802,‡ under the name *Clupea tyrannus*. Although this article, and the name therein proposed, have long since been lost sight of, there can be little doubt that they refer to the menhaden, and that the laws of priority demand that the species shall henceforth be known as *Brevoortia tyrannus*. The fishes of the Chesapeake and its tributaries have, until within the past three years, been very little studied, and the habits of the menhaden in those waters are so different that it is not strange for Northern ichthyologists to have made mistaken identifications of Latrobe's specific name.§ In fact, it was supposed, not many years since, that the southern limit of the menhaden was north of the Capes of Delaware, while its habit of ascend-

* New English Canaan; or New Canaan; containing an abstract of New England. Force's Hist. Tracts, vol. ii, Tract 5.

† An Account of two voyages to New England, a Description of the country, natives, and creatures. By John Josselyn, Gent. 1675. Col. Mas. Hist. Soc., 3d series, III. 1833.

‡ A Drawing and Description of the Clupea Tyrannus and Oniscus prægustator. By Benjamin Henry Latrobe, F. A. P. S. < Transactions of the American Philosophical Society held at Philadelphia for promoting useful knowledge. Vol. V, 1802, p. 77.

§ Dr. Dekay, misled by the name "alewife," which he supposed to be applied to the same species at the north as in southern waters, applied Latrobe's name to the northern "alewife," calling it *Alosa tyrannus*, a usage which was concurred in by Storer and by Cuvier and Valenciennes. The same name was referred to the shad by Professor Gill in some of his earlier writings.

ing the rivers of the South and the presence of the peculiar parasite were quite unknown.

Latrobe's description is reproduced in Appendix D, and the reader may decide the question for himself. It is believed that the following circumstances clearly indicate the meaning of its author:

(1.) The figure, while undeniably bad, resembles the menhaden very closely, and manifestly cannot be intended to represent any allied species. The contour, were the missing dorsal fin supplied, is similar to that of the menhaden, the black spot upon the scapular region is constant in the menhaden only, though a similar one is occasionally seen upon the shad and the alewife. While the figure resembles somewhat the menhaden, it does not resemble the allied species.

(2.) The name "bay alewife" is still applied to the menhaden in this region. This is a strong argument, for, although seventy-five years have passed since Latrobe wrote, the persistence of popular names is very remarkable, as I have elsewhere pointed out.* Moreover, Latrobe was also acquainted with a "herring" and a "shad." These being eliminated, there is no fish but the menhaden to which the description in question can refer.

(3.) The habits of the alewife as described by Latrobe are essentially the same as those of the menhaden in the present day. As has been remarked, it is only recently that the river-ascending habits of the species have been understood, and the statement that the alewife began to ascend the Potomac in March, which was two months earlier than the menhaden was known to strike our coast, formerly was thought to throw the identity of the two out of question.

(4.) The presence of the crustacean parasite is the strongest argument of all. While this is found in the mouths of a large percentage of the southern menhaden, it has never once been found attached to any other species, although careful search has been made by several persons. As has been remarked, the northern menhaden are free from this parasite, and this is still another reason for the failure to identify.

31. The next mention of this species was by Professor Mitchill, under the name *Clupea menhaden*.† By this specific name it has been known ever since, and it is to be regretted that it is necessary to replace by another a name so appropriate and of such long standing.

Descriptions of later dates.

32. In 1818, the eccentric Rafinesque redescribed the species as *Clupea neglecta*, the specific name being chosen because he supposed the species to have been neglected by Dr. Mitchill in his comprehensive catalogue of the fishes of New York.‡

---

* Catalogue of the Fishes of the Bermudas, 1876, p. 15.

† The fishes of New York described and arranged. < Transactions of the Literary and Philosophical Society of New York, Vol. I, 1815, p. 453.

‡ American Monthly Magazine, Vol. II, 1818, p. 206.

33. In Belknap's History of New Hampshire, this species is mentioned under the name "*Clupea dura lævi mystax* (hardhead)."* Since no description is given, this name can have no significance.

34. Mitchill's "New York Shadine" (*Clupea sadina*)† appears to be identical with *Brevoortia tyrannus*, as is indicated by the smutty opercular spot, the wide and toothless mouth, and protruding gill apparatus. The deciduous character of t' e scales may have been due to poor preservation of the type specimen.

Gronow, in 1763, described the species under the name *Clupea Carolinensis*,‡ but his manuscript was not published until 1854, and his name must yield precedence to those which are really much more recent.

The Gulf Menhaden.

35. A second North American species of menhaden has recently been discovered. A description will be given in a subsequent paragraph (42). This species has been reported only from the Gulf of Mexico. The name chosen for it has reference to the presence of a parasite which has already been mentioned, and which was described by Latrobe as the *Oniscus prægustator*. This parasite is common to both *Brevoortia tyrannus* and *Brevoortia patronus*, the gulf form; the specific name of the latter has been selected to carry out the quaint conceit of Latrobe, who fancied that the menhaden resembled a Roman ruler in having a "taster" who first tested every dish to prove its harmlessness.

The Menhaden of Brazil.

36. The species described, from Brazil, by Agassiz and Spix, under the name *Clupanodon aureus*§ does not appear to be distinctly separated from *Brevoortia tyrannus*. No diagnostic characters can be detected in the descriptions of either Agassiz or Günther; that is to say, characters which do not disappear upon the study of a large series of specimens. Agassiz's specimens, collected probably at Bahia, and in 1829 preserved in alcohol in the Munich Museum, were eight inches long. He himself seems to have had an inkling of their identity with the North American species, from the fact that he cites, doubtfully, as a synonym, Mitchill's *Clupea menada*. The difference in spelling this specific name is doubtless an attempt to put in Latin form the Indian name used by Mitchill. Two specimens from Sambaia, Brazil, and one from Rio Janeiro, collected by the Thayer expedition, agree closely with the figure in Spix's

* Belknap's History of New Hampshire, 2d ed., 1813, III, p. 133.

† Trans. Lit. and Phil. Soc., N. Y., 1814, pp. 457, 458.

‡ Catalogue of Fish, collected and described by Lawrence Theodore Gronow, now in the British Museum. Published by order of the Trustees, London, 1854, pp. 140.

§ Selecta | Genera et Species | Piscum | quos | in Itinere per Brasiliam | Annis MDCCCXVII-MDCCCXX | * * * | collegit, et pingendos curavit | Dr. J. B. de Spix, | * * * | digessit, descripsit, et observationis anatomicis illustravit | Dr. L. Agassiz, | * * * | Monachii, | Typis C. Wolf | = | 1829, p. 52.

work. The species is not well separated, and is at best but a geographical race of *Brevoortia tyrannus.*

Darwin's Menhaden.

37. The *Alosa pectinata* described by Jenyns,* from specimens collected by Charles Darwin at Bahia Blanca, appears to be a well-defined species, distinguished chiefly by the lesser number of transverse rows of scales. In the Natural Museum is a specimen (No. 1709) collected by Captain Page, U. S. N., in the expedition of the United States steamer "Waterwitch" to Paraguay. The extremely pectinate scale, given in the figure of *Alosa pectinata*, and upon which so much stress is laid by Mr. Jenyns, is taken from one of the differentiated rows immediately in front of the dorsal fin, which are alike pectinate in all species of the genus. Two specimens belonging to the Museum of Comparative Zoology, collected in the Rio Grande, agree thoroughly with Mr. Jenyns' description and with the Paraguay specimens already referred to.

Generic relations.

38. Dr. Storer first referred the species to the genus *Alosa*, where it stood until 1861, when Professor Gill proposed for it a new genus, which he named *Brevoortia*, in honor of the Hon. J. Carson Brevoort, of New York City. This genus is characterized by peculiarities of structure in scales, gills, gill-rakers, and alimentary canal.

A revision of the American species.

39. The type of the genus *Brevoortia* of Gill is the species described in 1802 by Latrobe under the name *Clupea tyrannus*, and later by Mitchill under the name *Clupea menhaden.* As has already been indicated (Proceedings U. S. National Museum, vol. 1, p. 5), the former name has the prior claim to adoption, and the species must be called *Brevoortia tyrannus.* Of this species there appear to be two geographical races or subspecies. One of these is the typical form of the Atlantic coast of the United States, the other a closely-allied form from the coast of Brazil, already described by Spix under the name of *Clupanodon aureus.* For the species the name of Latrobe should be retained, and the two subspecies may be distinguished as *Brevoortia tyrannus, menhaden* and *Brevoortia tyrannus, aurea:* a third subspecies is temporarily adopted to include some aberrant forms from Noank, Conn., for which the name *Brevoortia tyrannus brevicaudata* is proposed. On the coast of Patagonia and Paraguay occurs a well-marked species, described by Jenyns under the name of *Alosa pectinata.* This species is readily distinguished by its larger scales, which are arranged in 18 to 20 lateral rows, instead of 25 to 27, as in *B. tyrannus.* The generic relations of this species were recognized many years ago by Professor Gill, and its name should stand as *Brevoortia pectinata*, (Jenyns) Gill.

---

*The Zoology of the Voyage of H. M. S. Beagle, &c. * * * Part IV. Fish. * * * London, 1842., p. 135, pl. xxv.

A third species occurs in the Gulf of Mexico. It is distinguished by its larger head and fins and other characters. It appears to have never been described, and, for this form, the name of *Brevoortia patronus* is proposed. It is accompanied by the same crustacean parasite that is found in the mouths of *B. tyrannus*, to which Latrobe gave the significant specific name of *prægustator*.

C.—DESCRIPTIONS OF THE AMERICAN SPECIES OF MENHADEN, WITH ANATOMICAL AND PHYSIOLOGICAL NOTES.

7.—TECHNICAL DESCRIPTIONS.

Brevoortia tyrannus.

40. The following is a careful description of the common menhaden, which occurs on the east coast of the United States and Brazil:

Brevoortia tyrannus (Latrobe) Goode. THE MENHADEN.

Diagnosis.—Head and jaws short; the length of the head less than one-third of the length of the body less the caudal fin; especially short in subsp. *aurea*, the maxillary in length much less than three-twentieths of the length of the body.

Height of body about one-third of total length, in very fat individuals about three-eighths. Fins comparatively short, the height of the dorsal less than length of maxillary, and considerably less than three-tenths of length of body; that of the anal usually less than half that of maxillary; that of ventral always less than one-tenth of total length; the length of middle caudal rays one-fifth that of body, and less that of exterior caudal rays, usually about three-fourths, often less than two-thirds, and rarely more than five sixths of total length. Fins all shorter in subsp. *aurea*. Insertion of ventral far behind tip of pectoral. Insertion of dorsal about equidistant from snout and base of middle caudal rays, but varying two or three one-hundredths to either side of this median point, and always slightly behind the vertical from insertion of ventral.

Scales of medium size, much serrated, arranged very irregularly in 24–26 transverse and 60–80 longitudinal rows. Scales forming sheath at base of pectoral not large. Squamation of caudal lobes moderate. Operculum strongly striated in subsp. *menhaden*, almost smooth in subsp. *aurea*. Scapular blotch conspicuous.

This species is easily distinguished from *Brevoortia patronus* by its shorter head and fins, by its slender body and its pectinated scales, and from *B. pectinata* by its smaller, less regularly arranged, and more numerous scales, and its shorter, less furcate caudal fin.

Individual variations and special descriptions.

Head.—The length of the head varies from 28 to 33 hundrdths of total length. The posterior end of the maxillary extends to a point in the vertical from the centre of the orbit. The length of the skull, as

indicated by the "distance from snout to nape," varies from .19 to .23. The length of snout, measured from a line drawn perpendicularly through the centre of the orbit, varies from .09 to .11. The length of maxillary varies from .12 to .14½; that of mandible from .15 to .18. The diameter of the eye enters 4½ times in the length of the head; its width varies from .11 to .15 in very fat individuals.

Shape of body.—This is exceedingly variable, and the variation is caused largely by the fatness of the individual. In very plump ones, the expansion of the belly throws back the origin of the ventrals and anal, and greatly changes the appearance of the fish. In the specimens before me the height of the body ranges from .31 to .38½. The table of measurements subjoined shows the effect of increased height of body upon the other measurements of proportion.

Fins.—The range of variation in the position of the dorsal is indicated in the diagnosis. There is no appreciable correlation between the positions of the dorsal and anal in the same specimen. The insertion of the anal is distant from the snout from .68 to .75. The length of the rays in dorsal, anal, ventral, and caudal vary much, as the table of measurements indicates. In the caudal the upper lobes vary from .16 to .25, the lower lobes from .18 to .27. The relation of the pectoral and ventral fins is much affected by the length of the head, the insertion of the former being thrown much farther back in long-headed individuals.

Scales.—The degree of serration varies much in individuals as well as the squamation of the bases of the vertical fins, and the number and regularity of the body-scales. In young individuals the scales are arranged with much regularity, but in the adults I have strong reason to believe that other scales are intercalated here and there throwing the arrangement into great disorder and rendering an accurate enumeration impossible.

Subspecies.

The series before me embraces some two hundred specimens of *Brevoortia tyrannus* of various ages, seasons, and localities. Almost every feature is subject to wide variations, and there is usually no decided correlation between different characters except that a long head is accompanied by long jaws and a pectoral set farther back and extending more nearly to the insertion of the ventral. There are, however, certain groups of individuals which can be included within a diagnosis, which may serve to distinguish them from all the others of the same species. To what extent it is desirable to define varieties which are not separated geographically, I am not well satisfied. The exact meaning of the terms "sub-species" and "variety," as employed by Cope, Coues, Gill, Yarrow, and other recent writers, has not been definitely interpreted. It seems desirable, however, to designate in some way the limits of variation from the normal specific types in different directions. With this purpose, and remarking that by a subspecies I mean simply a divergent form connected by intermediate forms with the typical specific form, I have

thought it desirable to name provisionally two varieties, and to call attention to others which may possibly exist. This is done with much hesitation, and only with a view to an attempt to formulate the minor differences to be observed between fish of the same species on different parts of our coast. A precisely parallel case is to be found in the shad of the different Atlantic rivers, which are well-known to exhibit strong distinctive marks. Very possibly every school of menhaden has its own characteristics. In every case where I have had an opportunity to observe them, the individuals composing the same school were closely similar to each other.

The typical form of the species, as now defined, is taken from the coast of Southern New England and the Middle States. It has the height of the body about one-third of the total length, the head three-tenths of the total length, or a little more; the maxillary long (.14 to .14½), and exceeding the height of the dorsal.

The species described by Spix, under the name of *Clupanodon aureus*, cannot be distinguished by any apparent specific characters from *Brevoortia tyrannus*, since one or more of the specimens of the latter species before me partakes of some of the peculiarities of the Brazilian form. There is, however, a general average of character exhibited by the Brazilian specimens, as well as the figure of Spix, with which they closely agree, which seems to me to entitle them, for the present at least, to recognition as belonging to a distinct geographical race. The distinctive characters appear to consist in (1) a greater average height of body; (2) a lesser length of head; (3) a lesser average length of maxillary and mandible; (4) a slightly lower anal and dorsal fin; (5) a greater average distance of anal from snout; (6) a greater average length of the medial caudal rays; (7) a shorter average length of pectoral; (8) a more regular arrangement of the scales, and a more luxuriant growth of small scales at the basis of the fins.

A number of specimens from Noank, taken in 1874, vary quite as much from the normal type, and in almost the same respect as the variety just described. The maxillary and mandible are shorter, however, than in the Brazilian form, the anal fin lower and the lobes of the caudal are extremely short, sometimes hardly exceeding in length the pectoral fin. But for the fact that these specimens show almost all the characters of the Brazilian *Brevoortia*, and in some cases exaggerations of them, I should be inclined to consider the *aurea* a distinct species. Having with some hesitation allowed to this the rank of a subspecies, the question must be decided as to the propriety of also allowing subspecific rank to this peculiar form from Noank. The exact meaning of the terms subspecies and variety, as recently employed by zoologists, is not very clear to my mind, but I infer a "subspecies" to be composed of an assemblage of individuals varying uniformly from the typical specific forms in a degree sufficient to be susceptible of description and definition, though not necessarily separated from it by the absence of

connecting forms. Premising, then, that in giving to the Noank specimens a subspecific name, my object is simply to define the limits of variation from the normal type in a given direction, I would provisionally propose that they be designated as subspecies *brevicaudata*.

The specimens from the Saint John's River, Florida, are extremely variable in every respect. Certain individuals show a tendency to elongation of the head and fins, and also a slenderness of the posterior part of the body, and nearly all the individuals from that region are more lightly and gracefully shaped; they all have a tendency to a yellow coloration, especially upon the caudal lobes. I have not felt justified, however, in calling it a subspecies.

I have not had an opportunity to study the Maine schools, but am inclined to believe that their differences are very perceptible.

In plate VI are shown the chief variations of form. Fig. 1 shows the typical form; fig. 2 the subspecies *brevicaudata;* fig. 3 the average form from the Saint John's River, Florida; fig. 4 the subspecies *aurea.*

Table of measurements.

Current number of specimen	10,405 = 709 C. A. S.		10,405 = orig. No. 247.		20,666 *a.*	
Locality	Wood's Holl.		Wood's Holl.		Wood's Holl.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
	Very fat.		*Plump.*			
Extreme length	251	....	243	....	130	....
Body:						
Greatest height	....	38½	....	31½	....	34½
Least height of tail	....	9	....	....	....	....
Length of caudal peduncle	....	9½	....	....	....	....
Head:						
Greatest length	....	32	....	31	....	31
Distance from snout to nape	....	20	....	20½	....	20½
Greatest width	....	15	....	....	....	....
Length of snout from perp. from centre of orbit.	....	10	....	10	....	10½
Length of operculum	....	9	....	9	....	9
Length of maxillary	....	14½	....	14½	....	14
Length of mandible	....	17¾	....	17¾	....	17
Distance from snout to center of orbit	....	10½	....	10¾	....	10⅝
Dorsal:						
Distance from snout	....	54	....	51	....	49
Length of base	....	19	....	17½	....	17½
Origin of pectoral to origin of dorsal	....	41	....	33¾	....	35½
End of dorsal to end of anal	....	25½	....	24	....	25
Length of longest ray	....	12½	....	11	....	12½
Length of last ray	....	6	....	7	....	6½
Anal:						
Distance from snout	....	73	....	72	....	72
Length of base	....	14	....	14½	....	15½
Origin of anal to origin of dorsal	....	39	....	33	....	36
Length of longest ray	....	6½	....	5½	....	6¾
Length of last ray	....	5½	....	4½	....	4½
Caudal:						
Length of middle rays	....	5½	....	4½	....	5½
Length of external rays, superior	....	23	....	20½	....	20
inferior	....	26½	....	23	....	23
Pectoral:						
Distance from snout	....	30	....	32	....	30
Distance of tip from snout	....	48½	....	48	....	46
Length	....	19	....	17½	....	18
Length of longest axillary appendage	....	11	....	....	....	....
Ventral:						
Distance from snout	....	53	....	53	....	51
Length	....	8½	....	7½	....	9
Origin of ventral to end of dorsal	....	38	....	31	....	33
Dorsal	18	....	20	....	20	....
Anal	21	....	20	....	21	....
Number of scales in lateral line	94	....	107	....	....	....

Table of measurements—Continued.

Current number of specimen	20,666 *b*.		18,049 *b*.		1,696 *a*.	
Locality	Wood's Holl.		Saint John's River.		Indian River, Florida.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	132		140		*Fat.* 196	
Body:						
Greatest height		34		34		37
Head:						
Greatest length		32		30		30
Distance from snout to nape		23		21		20
Greatest width				11		
Length of snout from perp. from center of orbit		11½		10		10
Length of operculum		9		9½		9
Length of maxillary		14½		13		13½
Length of mandible		17½		16		17
Distance from snout to center of orbit		12				
Dorsal:						
Distance from snout		53		49		50
Length of base		19		18		17
Origin of pectoral to origin of dorsal		35		34		36
End of dorsal to end of anal		24		26		30
Length of longest ray		12		12		13
Length of last ray		6		6½		5
Anal:						
Distance from snout		72		71		72
Length of base		15		16		16
Origin of anal to origin of dorsal		34		36		38
Length of longest ray		6½		8		*5+
Length of last ray		5		5		*3+
Caudal:						
Length of middle rays		6		6½		*4+
Length of external rays, superior		22½		24		*22
inferior		27		27		*24
Pectoral:						
Distance from snout		32		30		30
Distance of tip from snout		48½		47		
Length		18		17		
Ventral:						
Distance from snout		52		50		50
Length		9½		9		
Origin of ventral to end of dorsal		33		33		35
Dorsal	20		19		18	
Anal	21		20		20	

Current number of specimen	5,152.		17,927.		19,046.	
Locality	West Florida.		Saint John's River, Fla.		Saint John's River, Fla.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	101		(*7-inch.*) 178		230	
Body:						
Greatest height		38		34¾		32
Least height of tail				10		9
Length of caudal peduncle				8		8
Head:						
Greatest length		29		31½		33
Distance from snout to nape		20		20½		20½
Greatest width				12		12
Length of snout from perp. from center of orbit		10		10		10½
Length of operculum		9½		9½		9½
Length of maxillary		13		14		14½
Length of mandible		15		18		18
Distance from snout to center of orbit				11½		10½
Dorsal:						
Distance from snout		48		52		52½
Length of base		18		21		17
Origin of pectoral to origin of dorsal		36		34½		34
End of dorsal to end of anal		30		26		25
Length of longest ray				12		12
Length of last ray				5		

* Broken.

Table of measurements—Continued.

Current number of specimen	5,152.		17,927.		19,046.	
Locality	West Florida.		Saint John's River, Fla.		Saint John's River, Fla.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Anal:			(7-*inch.*)			
Distance from snout				68		72
Length of base				16		16
Origin of anal to origin of dorsal				38		32½
Length of longest ray				6½		6
Length of last ray				5		6½
Caudal:						
Length of middle rays				5		5½
Length of external rays, superior				21		20
inferior				23		24
Pectoral:						
Distance from snout				31½		32
Distance of tip from snout				49		50
Length				19		18
Length of longest axillary appendage				12		
Ventral:						
Distance from snout				49		48
Length				9		9
Origin of ventral to end of dorsal				33½		30
Dorsal	20		21		18 or 19	
Anal	21		21		21	

Current number of specimen	19,044.		18,049 *a.*		19,468.	
Locality	Saint John's River, Fla.		Saint John's River, Fla.		Virginia.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	192		144		234	
Body:						
Greatest height		34		34		32
Least height of tail						9
Length of caudal peduncle						9
Head:						
Greatest length		29		29		32¼
Distance from snout to nape		19		19		20¾
Greatest width		12		11		12
Width of interorbital area						7
Length of snout from perp. from center of orbit		9½		10		10
Length of operculum		10		10		9
Length of maxillary		13		13		14
Length of mandible		16		16½		18
Distance from snout to center of orbit		10		11		11
Dorsal:						
Distance from snout		49		49		51
Length of base		17		17		18½
Origin of pectoral to origin of dorsal		35		35		34
End of dorsal to end of anal		27		29		23
Length of longest ray		12		12½		11
Length of last ray		6		6½		5½
Anal:						
Distance from snout		71		71		72
Length of base		17		17½		14½
Origin of anal to origin of dorsal		34		37		33
Length of longest ray		6		7		5¼
Length of last ray		6		4		6
Caudal:						
Length of middle rays		6		5		4
Length of external rays, superior				25		
inferior		23		27		24
Pectoral:						
Distance from snout		30		30		32
Distance of tip from snout		45		45		49
Length		16		17		18
Length of longest axillary appendage						12
Ventral:						
Distance from snout		49		50		51
Length		9		8½		9
Origin of ventral to end of dorsal		34		34		30
Dorsal	19		18		19	
Anal	23		21		21	

Table of measurements—Continued.

Current number of specimen	14,846 *a.*		14,846 *b.*		Brevoortia aurea. M. C. Z.	
Locality	Noank.		Noank.		Rio Janeiro.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	157		156		236	
Body:						
Greatest height		34		34½		35
Head:						
Greatest length		29		28		27½
Distance from snout to nape		20				21
Length of snout from perp. from center of orbit		10		9		10
Length of operculum		9½				
Length of maxillary		13		12		12
Length of mandible		14½		14		15
Distance from snout to center of orbit		10				
Dorsal:						
Distance from snout		49		47		51
Length of base		19		20		
Origin of pectoral to origin of dorsal		35		34		
End of dorsal to end of anal		25		25		
Length of longest ray		10		9		10
Length of last ray		6		6		4
Anal:						
Distance from snout		74		72½		73
Length of base		15		16		
Origin of anal to origin of dorsal		36½		37		
Length of longest ray		4½		5		5
Length of last ray		4		4½		4
Caudal:						
Length of middle rays		4½		5½		5
Length of external rays, superior		17		16		23
inferior		18		20½		
Pectoral:						
Distance from snout		28		28		28
Distance of tip from snout		41		43		42
Length		12		15		15
Ventral:						
Distance from snout		52		50		49
Length		7		7		8
Origin of ventral to end of dorsal		34		36		
Dorsal	20		20		II 17	
Anal	19		20		19	

Current number of specimen	B. aurea, A.		B. aurea, B.		Average.
Locality	M. C. Z. Sambaia.	Thayer Exp.	M. C. Z. Sambaia.	Thayer Exp.	
	Millim.	100ths.	Millim.	100ths.	100ths.
Extreme length	164		154		
Body:					
Greatest height		37		34	35
Head:					
Greatest length		28		29	28
Distance from snout to nape		19		22	21
Length of snout from perp. from center of orbit		9		10	09⅔
Length of maxillary		13		14	13
Length of mandible		15		17	15⅔
Dorsal:					
Distance from snout		49		48	49⅓
Length of longest ray		12		10	10⅔
Length of last ray		5		5	04⅔
Anal:					
Distance from snout		75		73	73⅔
Length of longest ray		6		5	05⅓
Length of last ray		4		3	03⅔
Caudal:					
Length of middle rays		6		5	05⅓
Length of external rays, superior / inferior		25		23	23⅔
Pectoral:					
Distance from snout		29		30	29
Distance of tip from snout		44		47	44⅓
Length		16		16	15⅔
Ventral:					
Distance from snout		53		52	51⅓
Length		7		7	07⅓
Dorsal	II. 17		II. 17		
Anal	20		22		

Brevoortia patronus.

41. The following is a careful description of the new species of *Brevoortia* from the Gulf of Mexico:

Brevoortia patronus, *spec. nov.* Goode. THE GULF MENHADEN.

Diagnosis.—Head larger than in the other American forms; its length usually more than one-third that of the body, the maxillary about three-twentieths of the length of the body.

Height of body always more than three-eighths of its total length, its anterior inferior profile cultrate, convex, giving an obtusely rounded profile to the subpectoral outline, and throwing the snout above the median horizontal axis of the body. Fins long and powerful; the height of the dorsal usually equal to the length of the maxillary and about three-tenths of total length of body; that of the anal equal to a greater than half the length of the maxillary; that of the ventral one-tenth of body-length; length of middle caudal rays always more than one-fifth and often more than one-fourth the length of the head; that of the exterior rays almost equal in length to the head and rarely less than five-sixths of its length. Insertion of the ventral under or slightly posterior to the tip of the pectoral. Insertion of dorsal always posterior to a point on the dorsal outline equidistant from the snout and the base of the medial caudal rays (sometimes as much as seven-one-hundredths of total length), and always in advance of the vertical from the insertion of the ventral.

Scales of medium size, with entire fluted margins arranged regularly (in young) in 24–25 transverse and 50–70 longitudinal rows. Scales forming sheath at base of pectoral very large, round squamations of caudal lobes inconspicuous. Axillary appendages large. Operculum smooth or very delicately striated; scapular blotch inconspicuous.

The variations of individuals are sufficiently indicated in the subjoined table of measurements. The most characteristic specimens occur at Brazos Santiago, Tex., and the more northern specimens show a tendency to shortening up of the head, jaws, and fins.

* *Description.*—The body is much compressed, especially below and in advance of the pectorals; the contour of the belly between the ventrals and the gill-opening is cultrate, projecting, obtusely rounded. The height of the body equals two-fifths of its length, and the least height of the body at the tail is one-fourth of its greatest height in front of the pectorals. The length of the caudal peduncle, from the end of the anal to the base of the exterior lobes of the caudal, is one-fifth of the height of the body and one-twelfth (.08) of its length.

The head is elongated and large, triangular; its length is more than one-third (.35 and .34) that of the body, and its height at the nape is slightly more than its length. The length of the skull, as indicated by the distance from snout to nape, is about one-fourth (.24 and .24½) of the

* To avoid confusion this is drawn up from the Brazos Santiago specimens, which are most characteristically developed.

length of the body, and the greatest width of the head (.13) slightly exceeds the half of this. The width of the interorbital is about equal to the diameter of the orbit and slightly more than one-fourth the length of the head. The maxillary reaches to the vertical from the posterior margin of the pupil; the mandible nearly to the vertical from the posterior margin of the orbit. The length of the maxillary is about equal to that of the longest ray of the dorsal fin (.15 to .16); that of the mandible (.19), to half the distance from the origin of the anal to the origin of the dorsal (.38), or to the length of the base of the anal (.18). The distance from the tip of the snout to the center of the orbit (.13 to .13¾) equal the greatest width of the head. The length of the operculum is equal to that of the eye; the opercular striations are fine, but distinct and numerous. The dorsal fin is inserted posteriorly to a point equidistant from the snout and the base of the caudal, and in advance of the vertical from the insertion of the ventrals. Its length of base (.20 to .21½) is double that of the operculum. Its greatest height is nearly half the length of the head. It is composed of 19 rays, of which the third is the largest. Its upper edge is slightly emarginated. The height of the last ray (.10) is equal to half the length of the base. The distance of the anal from the snout is slightly less than three-fourths of the length of the body (.70–.72); its length of base (.18–.18½) one-fourth of this distance. The distance from the origin of the pectoral to the origin of the dorsal (.37–.37½) is about equal to that from the origin of the anal to that of the dorsal (.38). Its height (.9–.9½) is about half its length of base; its least height (at last ray), one-third of the same (.6–.5½). The fin is composed of 22 rays, its edge slightly emarginated. The caudal fin is much forked and elongate; the middle caudal rays (.08) half the length of the maxillary; the exterior rays above (.31–.32) twice that length; the lower exterior rays (.35–.34) nearly equal to twice the length of the mandible.

The pectoral fin is strong, falcate, inserted under the angle of the suboperculum at a distance from the snout (.35–.34) about midway to the insertion of the anal. Its tip extends beyond the insertion of the ventrals, its length (.22) being nearly two-thirds that of the head. The axillary appendages are half as long as the fin, or more.

The distance of the ventral from the snout (.54–.55) is about the same as that of the dorsal, though by the contour of the body it is thrown slightly behind the point of dorsal origin. Its length (.10) is equal to that of the last ray of the dorsal. The scales are quite regularly arranged in about 24 to 25 horizontal and 50 vertical rows. Their free portion is narrow and high. They are entire at the edges and fluted or crenulated. There are two rows of differentiated scales upon each side of the dorsal line, but they are scarcely pectinated. The scales forming the sheath at the base of the pectoral are large and round. Color: silvery, with a brassy sheen upon the sides and greenish-gray upon the back.

Table of measurements.

Current number of specimen	892 *a*.		892 *b*.		891 *a*.	
Locality	Brazos Santiago, Tex.		Brazos Santiago, Tex.		Mouth of Rio Grande.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	106		104		96	
Body:						
Greatest height		40½		40½		38
Least height of tail		11		10		10
Length of caudal peduncle		8		8		
Head:						
Greatest length		25		34		33
Distance from snout to nape		24½		24		23½
Greatest width		13		13		11
Length of snout from perp. from center of orbit		12		11½		12
Length of operculum		10		10		11
Length of maxillary		16		15¾		16
Length of mandible		19		18½		19
Distance from snout to center of orbit		13¾		13		12½
Dorsal:						
Distance from snout		53		53½		51
Length of base		21½		20		17
Origin of pectoral to origin of dorsal		37		37½		37
End of dorsal to end of anal		25		26		26
Length of longest ray		15		16		14½
Length of last ray		10		9		7½
Anal:						
Distance from snout		72		70		70½
Length of base		18½		18		19
Origin of anal to origin of dorsal		38		38		36
Length of longest ray		9		9½		7½
Length of last ray		6		5¼		5
Caudal:						
Length of middle rays		8		8		8
Length of external rays, inferior		31		32	(*) (†)	26 28
Pectoral:						
Distance from snout		35		34		33½
Distance of tip from snout		55		54		53
Length		22		22		18½
Length of longest axillary appendage		11		13		
Ventral:						
Distance from snout		53		52		54
Length		10		10		10
Origin of ventral to end of dorsal		36		35		33
Dorsal	19		19		18	
Anal	22		22		22	
Number of scales in lateral line	47 to 50		47 to 50		‡65	

Current number of specimen	891 *b*.		891 *c*.		5,864 *a*.	
Locality	Mouth of Rio Grande.		Mouth of Rio Grande.		New Orleans Academy.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	90		73		86	
Body:						
Greatest height		41½		40		38
Least height of tail		11				
Length of caudal peduncle		7½				
Head:						
Greatest length		33		30		32
Distance from snout to nape		23		22½		23
Greatest width		11				
Length of snout from perp. from center of orbit		11		11½		12
Length of operculum		12		10		10
Length of maxillary		14½		14		14
Length of mandible		18		17½		17
Distance from snout to center of orbit		13		12		
Dorsal:						
Distance from snout		52		57		50
Length of base		19		17		16
Origin of pectoral to origin of dorsal		39		37		36
End of dorsal to end of anal		28		27		31
Length of longest ray		17		14		14
Length of last ray		9		7		8

* Superior. † Inferior. ‡ About.

Table of measurements—Continued.

Current number of specimen	891 *b.*		891 *c.*		5,864 *a.*	
Locality	Mouth of Rio Grande.		Mouth of Rio Grande.		New Orleans Academy.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Anal:						
Distance from snout		69		69		72
Length of base		20		19		19
Origin of anal to origin of dorsal		39		37		37
Length of longest ray		8½		7	(*)	7
Length of last ray		4½		5	(*)	5
Caudal:						
Length of middle rays		7		9		7
Length of external rays, superior		25+		27		27
inferior		27+		27		30
Pectoral:						
Distance from snout		32		30		33
Distance of tip from snout		52		47		48
Length		20		17		18
Length of longest axillary appendage						
Ventral:						
Distance from snout		51		52		53
Length		9½		10		9
Origin of ventral to end of dorsal		35		16		32
Dorsal	18		18		19	
Anal	22		21		22	
Number of scales in lateral line	†65		‡65		†70	

Current number of specimens	5,864 *b.*		5,864 *c.*	
Locality	New Orleans Academy.			
	Millim.	100ths.	Millim.	100ths.
Extreme length	81		74	
Body:				
Greatest height		36		38½
Head:				
Greatest length		30		33
Distance from snout to nape		21½		24
Length of snout from perp. from center of orbit		10		11
Length of operculum		10		10
Length of maxillary		13½		14½
Length of mandible		16		17½
Dorsal:				
Distance from snout		57		52
Length of base		18½		19
Origin of pectoral to origin of dorsal		33		36
End of dorsal to end of anal		26		25
Length of longest ray		12		14
Length of last ray		5½		7
Anal:				
Distance from snout		70		70½
Length of base		17		19
Origin of anal to origin of dorsal		36		37
Length of longest ray		6		9
Length of last ray		4		6
Caudal:				
Length of middle rays		6		9½
Length of external rays, inferior		25		
Pectoral:				
Distance from snout		30		32
Distance of tip from snout		47		50
Length		17		19
Ventral:				
Distance from snout		53		52
Length		8		10
Origin of ventral to end of dorsal		32		35
Dorsal	18		19	
Anal	20		21	
Number of scales in lateral line	†55		†55	

* Imperfect. † About. ‡ Or more.

Brevoortia pectinata.

42. The following is an exact description of Jenyns species of *Brevoortia* from the Atlantic coast of Paraguay and Patagonia:

Brevoortia pectinata (Jenyns) Gill. DARWIN'S MENHADEN.

Diagnosis.—Proportions of head and jaws as in *B. tyrannus.* Height of body almost three-eighths of total length, and greater proportionally than in *B. tyrannus.* Fins nearly as in *B. tyrannus*, but uniformly averaging slightly more; the height of the dorsal somewhat less than three-twentieths of total length; that of the anal equal to or slightly less than half the length of the maxillary. The caudal fin is somewhat longer and more furcate; the length of the external rays never being less than five-sixths of the length of the head, while that of the medial rays remains proportionally the same as in the species first described. Insertion of ventral somewhat behind tip of pectoral, this fin and this dorsal being uniformly somewhat farther back than in *B. tyrannus;* the insertion of the latter from one to four one-hundredths posterior to a point equidistant from the snout and the base of the median caudal rays, and, as in *B. tyrannus*, behind the vertical from the insertion of the ventrals.

Scales very large, considerably serrated, and arranged regularly in 18–20 transverse and 50 longitudinal rows.

Scales forming sheath at base of pectoral not large. Operculum smooth or with inconspicuous and few striations. Squamation upon lobes of caudal extensive and conspicuous.

Variations.

The variations in the individual specimens studied are not of great importance, and are indicated in the tables of measurements.

Table of measurements.

Current number of specimen	1,709.		A.		B.		Average.
Locality	Paraguay.		M. C. Z. Rio Grande.		M. C. Z. Rio Grande.		
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.	100ths.
Extreme length	250	......	224	......	209	......	......
Body:							
Greatest height	......	35	......	36½	......	36	36
Head:							
Greatest length	......	33	......	30	......	30	31
Distance from snout to nape	......	21	......	21	......	21	21
Length of maxillary	......	14½	......	13	......	14	14
Length of mandible	......	18	......	16	......	16½	17
Dorsal:							
Distance from snout	......	54	......	53	......	51	52⅔
Length of longest ray	......	12½	......	12	......	12	12
Length of last ray	......	6	......	6	......	6	6
Anal:							
Distance from snout	......	70½	......	70	......	72	71
Length of longest ray	......	7	......	6	......	5	6
Length of last ray	......	6	......	4	......	4	4⅔

Table of measurements—Continued.

Current number of specimen	1,709.		A.		B.		Average.
Locality	Paraguay.		M. C. Z. Rio Grande.		M. C. Z. Rio Grande.		
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.	100ths.
Caudal:							
Length of middle rays	....	6½	....	6	....	6	6
Length of external rays, superior	....	24+	....	25	....	25	25
inferior	....	26	....	27	....	28	27
Pectoral:							
Distance from snout	....	32	....	29	....	30	30⅓
Distance of tip from snout	....	50	....	47	....	47	48
Length	....	18	....	17	....	18	17⅔
Ventral:							
Distance from snout	....	51½	....	48	....	49	49½
Length	....	9½	....	8	....	8½	8⅔
Dorsal	19	....	II. 17	....	II. 17	....	....
Anal	22	....	I. 20	....	I. 20	....	....
Number of scales in lateral line	*50	....	49	....	49	....	....
Number of transverse rows	*20	....	20	....	20	....	....

*Approximately.

8.—Size and rate of growth.

Length and weight.

43. The largest specimen on record is represented by a plaster cast in the National Museum, which is 20 inches in length. The average size of the fish upon the coast of Connecticut and Massachusetts is not far from 12 to 15 inches. The United States Menhaden Oil and Guano Association, in estimating the number of fish in a certain bulk, allow 22 cubic inches to each fish. The relation between length and weight is indicated in the following measurements, made at Noank, Conn., in 1875. These fish were all members of the same school.

Number.	Length.	Weight.	Number.	Length.	Weight.
	Inches.	*Ounces.*		*Inches.*	*Ounces.*
1	12½	11	16	12½	12
2	12¼	10	17	12	11
3	12½	11	18	12	11
4	12¼	12	19	12½	12
5	12⅓	12	20	12½	12
6	13	13	21	12½	11
7	12	11	22	12	10
8	12⅓	12	23	12	11
9	12½	12	24	13	12
10	12½	12	25	12½	12
11	12½	11	26	12	11
12	12½	13	27	12	11
13	12½	12	28	12	11
14	13	16	29	12	11
15	13	12	30	12	11

Variations in the schools.

44. The table given in the preceding paragraph indicates a very decided uniformity in the size of the individuals making up the same school. I have observed this uniformity in many schools, though I have not often measured many individuals from the same school. This

uniformity in length and weight is less remarkable, however, than the uniformity to be noticed in the shape and proportions of the members of the same schools. Variations are chiefly observable in the thickness and height of the body and the head and in the length of the fins, especially the pectorals and the caudal. These differences in shape are necessarily correlated with the activity and swiftness of the fish. Hence the differences in the wariness, swiftness, and difficulty in capture, so often referred to by old menhaden fishermen.

As a general rule, according to Mr. Dudley, the fall fish are mixed together without reference to fatness; the latest ones, however, which are supposed to be the main fish on their southern migration, are generally fat.

Annual rate of growth.

45. The shad is supposed to attain its full size in four years. Captain Atwood believes that the mackerel requires an equal length of time in which to grow to its adult size of 17 or 18 inches. From studies made in 1856, he concluded that they grew to the length of 2 inches in about thirty days, and 4 inches in forty-five days, becoming 6½ or 7 inches long before the October migration, the spawning having taken place about the middle of May. In the second year they are the "blinks;" in the third, "tinkers;" and in the fourth, full-grown mackerel. The menhaden must require three and perhaps four years to attain adult size. Those which strike in at midsummer on the coast of New England are probably hatched from the eggs spawned in the previous fall and winter. They are from 2 to 5 inches long. The second year's growth is doubtless represented by the smallest sizes of the schooling fish, measuring from 7 to 10 inches, such as are catalogued in bottles Nos. 14045, 14846, and 18049. The third year's fish would be represented by the abundant schools of fish of 12 and 14 inches, like those with measurements specified in paragraph 43. The full-grown fish are the immense ones taken in Maine and Massachusetts, measuring 16 and 18 inches.

A most interesting circumstance is narrated by Mr. George W. Miles, to whom I am indebted for many very valuable suggestions utilized elsewhere. His observations were made in Long Island Sound. He writes:—"In 1873 there were immense numbers of small fish, from 1 to 2 inches long, which appeared on the surface in the month of September. Thousands of schools could be seen at a time and great numbers in each school. They appeared to take possession of all the waters for the remainder of that season. In 1874 these fish appeared again, late in the season, and were about double the size they were in 1873. In 1875 they appeared again, much earlier, and in 1876 they came in about the first of June, having increased in size and numbers. Apparently they occupied the whole waters of the sound, so much so, that the larger fish which frequented the sound were actually crowded out of it or left for other waters, and remained off Block Island at sea the remainder of the

season, and gave up the field to be occupied by the smaller fish. The result of this abundance of small fish was a complete failure of the fishery for the two years 1875 and 1876. In 1877 we provided ourselves with smaller-meshed nets, and proceeded to catch the smaller fish, which had now attained about two-thirds the average size of fish in this locality and weighed about half a pound each. We could catch these by using nets of 2⅜-inch mesh. About 15,000,000 of them were taken by our twelve gangs." Mr. Miles's observations seem to indicate that the period of growth sometimes, if not always, extends over a period of five or six years.

Seasonal rate of growth.

46. There is probably a much greater proportional increase in the size of individuals in the three or four months of their sojourn in northern waters than in the winter and spring. This is clearly indicated by the emaciated condition in which they make their first appearance in our waters, their winter's existence having been apparently sustained by the absorption of the fatty tissues elaborated in summer. Indeed, as will be shown below, there is some reason to believe that the winter months are passed in partial or total torpidity.

9.—COLOR AND OTHER MINOR CHARACTERISTICS.

Color of Northern fish.

47. The adult menhaden is a most beautiful fish. Its color is pearly opalescent, like that of the cyprinoid fishes from which the commercial *Essence d'Orient*, or liquid pearl, used by artists, and in the manufacture of paste jewelry, is prepared. Each scale has all the beauty of a fine pearl, and the reflections from the mailed side of a fish just taken from the water are superb. The scales of the back and the top of the head are of a purplish blue. The blotch of black upon the scapular region, just above the origin of the pectoral, is very constant, although I have seen fish in which it did not occur. Many, especially the older and fatter ones, have a number of irregular, roundish, blue-black blotches upon the sides and flanks. The young fish are not so brilliantly colored, and, in general appearance, resemble the young of the shad.

Color of Southern fish.

48. Many of the Southern fish show metallic, brazen, and golden reflections from the flanks and fins. Agassiz's *Clupanodon aureus*, from Brazil, was similarly colored. The name "yellow-tail," commonly applied to this species in the Southern States, is in common use as far north as Cape Hatteras.

Axillary appendages.

49. In the axils of the paired fins are long differentiated scales, which cover the angles of the fins, and are evidently intended to promote swift

progression in the water. Those attached to the pectoral are often nearly as long as the fin itself. A series of large shield-like scales cover the bases of these fins, apparently with the same object as the axillary scales. These are particularly large in the species from the Gulf of Mexico.

Scales.

50. The scales are, in the young fish, arranged in comparatively regular rows. In adult specimens of the *Brevoortia tyrannus* all semblance of regularity disappears, and it is impossible to count either longitudinal or vertical rows. The number of scales is enormously increased, apparently by the growth of additional scales in the interspaces between those already arranged in regular order. The number of scales in the longitudinal rows is from 60 or 70 in young individuals, to 110 in adults; in the vertical rows, 25 or 26.

10.—Internal organs.

Gill-strainers.

51. There are no vestiges of teeth in the mouths of any members of the genus *Brevoortia*. These fish do not feed upon living animals, and teeth would be useless to them. Their place is supplied by an arrangement of setiform appendages, attached to the anterior edges of the arches supporting the gills. These are closely set, flexible, and in *Brevoortia tyrannus* about 170 in number on each side of each of the arches. There being thus four rows upon each side of the mouth, there must be in the mouth of the menhaden from 1,400 to 1,500 of these thread-like bristles, from one-third to three-quarters of an inch long. These may be so adjusted that they form a very effective strainer, much resembling that of the right whale. This strainer is much finer and more effective than in the whale, the number of bristles being much more numerous than are the plates of baleen in the mouth of the right whale. The uses to which this strainer is applied will be discussed below, in paragraphs 119–125.

The accessory branchial organ.

52. There is also a curious accessory branchial organ, situated between the top of the fourth branchial arch and the base of the skull. This has been described from dissections of a fish identified as *Clupanodon aureus*, Spix, in a paper by Prof. Joseph Hyrtl,* cited in full in the Bibliography.

The alimentary canal.

53. The alimentary canal in the menhaden is peculiar. The pharynx is continued, in a straight canal, to the point of the siphonal stomach, which extends backward nearly to the posterior extremity of the intestinal cavity, then turning at an acute angle returns nearly to the

* Denkschriften Kaiserl. Akad. Wiss. Mat.-Nat. Class, vol. x, 1855, p. 49.

head, where it expands into a globular pear-shaped muscular organ with thick walls, which have their inner surfaces rugose, like those of the gizzard of a gallinaceous bird. At the anterior end of the stomach is a mass of fine, filiform, pyloric appendages, surrounding the origin of the intestine, which is very long and is arranged in two coils, one upon each side of the stomach, enveloping it completely. The length of the intestine is five or six times that of the whole fish.

The swim-bladder.

54. The swim-bladder is small and inconspicuous. Its walls are thin. It is not probable that it contains enough gelatine to be of commercial importance. Hyrtl was unable to detect its presence in the fish studied by him as *Clupanodon aureus*, but which was probably something very different.

III.—GEOGRAPHICAL DISTRIBUTION AND MOVEMENTS.

11.—GEOGRAPHICAL RANGE.

Limits in 1877.

55. It is not easy to define exactly the boundaries of geographical range for any species, unless they be marked by some impassable boundary. It is especially difficult in the case of fishes. The limits of their wanderings appear to depend directly or indirectly upon temperature, and to vary considerably, from season to season, with the seasonal variations in the mean temperature of the water.

As nearly as it can conveniently be expressed the range of the northern menhaden, *Brevoortia tyrannus*, is as follows: it is to be found at some period during the year in the coastal waters of all the Atlantic States from Maine to Florida (approximately between the parallels of north latitude 25° and 45°); on the continental side it is limited approximately by the line of brackish water; on the ocean side, by the inner boundary of the Gulf Stream. What may be the limits of its winter migrations it is impossible to say. A surface temperature of about 51° is necessary for its appearance in waters near the shores.

Variations of the northern limit in the past.

56. Its northern limit of migration seems to have always been the Bay of Fundy. Perley, writing in 1852, stated that they were sometimes caught in considerable numbers in weirs within the harbor of Saint John's, N. B.*

*Descriptive Catalogue (in part) of the fishes of New Brunswick and Nova Scotia, by M. H. Perley, esq., Her Majesty's emigration officer at St. John's, New Brunswick. (Second edition.) Fredericton: J. Simpson, Printer to the Queen's Most Excellent Majesty, 1852, p. 30.

Mr. G. A. Boardman, of Calais, Me., informs me that large schools have been seen during the summer in Passamaquoddy Bay and the lower Bay of Fundy.

James Lord, of Deer Island, Charlotte County, N. B., testified before the Halifax Commission that he had taken porgies in the neighborhood of Campo Bello, but that none had been seen there for ten years or more.*

Mr. J. F. Whiteaves declares that of late years none have been found in New Brunswick, nor to the north of Grand Manan.†

The claim of Professor Hind that they have been found as far north as Canso, is not, to my knowledge, supported by satisfactory evidence.

At present the eastward wanderings of the schools do not appear to extend beyond Isle au Haut and Great Duck Island. These islands are less than forty miles westward of the boundary of Maine and New Brunswick.

Southern limit of range.

57. Dekay supposed the southern limit of the menhaden to be in the neighborhood of Chesapeake Bay, but it has for some years been known that they occur in great abundance on the coast of North Carolina. I found them to be abundant in the Saint John's River, Florida, in March and April, 1874 and 1875, and it is quite certain that they are found there throughout the winter. In the National Museum are specimens (Catalogue No. 7696) collected at Indian River by Mr. Wurdemann. Mr. Charles Dougherty, of New Smyrna, Fla., tells me that he has observed numerous large schools during the winter in the open ocean off Cape Canaveral and Mosquito Inlet.

Old fishermen from Key West, who are perfectly familiar with the fish, assure me that it is never seen about the Florida Keys.

Oceanic limits of range.

58. Beyond these bounds nothing certain is known. The thorough and indefatigable labor of the twenty years during which Professor Poey has been investigating the ichthyology of Cuba justifies us in taking his word that the menhaden is not found in those waters. It has not been found at any other point in the West Indies, nor is it recorded from the coast of South America, though other species of the same genus have been found there. The investigations of Mr J. Matthew Jones and myself have failed to discover it about the Bermuda Islands, and it appears to be unknown to the fishermen at that point.

Menhaden in the Gulf of Mexico.

59. Mr. S. H. Wilkinson, keeper of Cat Island light-house, Mississippi Sound, writes that no fish resembling the menhaden is found in

* Proceedings Halifax Commission, 1877, Appendix F, p. 245.

† Sixth Report Department of Marine and Fisheries, Appendix U, p. 195.

those waters; and a similar statement is made by Capt. D. P. Kane, of the Matagorda light-station, Texas, who is a native of Maine, and has been engaged in pogy-fishing in that State. He has for the past eight years been engaged on the coast from Florida to Mexico, and has never seen menhaden or heard of their being caught south of Cape Hatteras, with one exception.

Capt. William Nichols, pilot, residing in Saluria, Tex., informed Captain Kane that in September, 1872, great quantities of pogies drifted upon the beach at Saluria, and that the waters of the Gulf of Mexico and Matagorda Bay were full of them. Capt. William E. Spicer, of Noank, Conn., is positive that he has encountered schools of these fish while seining for the Mobile market off Tampa, Fla.

These statements probably refer to the Gulf menhaden, recently discovered at various points in the northern Gulf of Mexico, and easily distinguished from the northern species.

Range of other species.

60. On the coasts of Brazil and at Montevideo occurs a geographical race of our northern species, the *Brevoortia tyrannus, aurea*, while still farther south, in the waters of Buenos Ayres, is another species, *Brevoortia pectinata*. The latter was first taken by Charles Darwin, on his memorable voyage around the world, in a net on a sand-bank at Bahia Blanca (latitude 39° S). Very probably the species is abundant along the coasts of the Argentine Republic, in the broad mouth of the Rio de la Plata, and from the analogy of our species, well up the southern coasts of Brazil, perhaps to Rio Janeiro. It is not unlikely that the eastern coast of South America is as abundantly supplied as our own with these most valuable fishes. Valenciennes states that the Portuguese of South America call the *Brevoortia aurea* by the name *Savega*.

Again, on the coasts of West Africa occurs a species, *Brevoortia dorsalis*, closely resembling the menhaden. An old fisherman in Maine told me that he had seen the menhaden in immense quantities on the western coast of Africa, where the negroes spear them and eat them.

Illustrations and descriptions of all the known American species are given elsewhere in this memoir.

Alleged occurrence on the Pacific coast.

61. The Hon. S. L. Goodale, of Saco, Me., writing under date October 25, 1877, states that some menhaden fishermen of Bristol, Me., have recently sent one of their number to prospect for them on the Pacific coast, and that his reports were so favorable that several of them with their families had left a few weeks previously for Washington Territory, where they were informed that "pogies" were abundant. If this report be true, it is quite certain that the explorers are doomed to disappointment. No fish resembling the menhaden occurs in the Pacific Ocean.

It should be noted, however, that wherever representatives of this genus of fishes occur there is doubtless an opportunity for establishing new industries of great value. It would be well worth while for enterprising fishermen to investigate this subject. The Government of Japan has recently employed one of the best informed of our New England fishermen * to instruct the natives of that country in the arts of catching and preserving food-fishes.

As has already been stated, there are abundant supplies of these fish on both sides of the South Atlantic. There is apparently no reason why extensive manufacturing interests may not be inaugurated in Brazil, the Argentine Republic, Paraguay, and Africa.

12.—THE ARRIVAL AND DEPARTURE OF THE SCHOOLS.

Causes influencing times of arrival and departure.

62. The date of the earliest appearance of the schools of menhaden at any given point upon the coast corresponds very closely with that of the arrival of scup, shad, bluefish, and other of the non-resident summer species. It depends primarily upon the temperature of the water. This element is of more importance, perhaps, in the case of the menhaden than with the carnivorous fishes, since the food-supply of the former is not likely to be affected by changes of temperature. There are other questions to be considered, such as the movements of hostile species and the direction of the prevailing winds, though the latter may, perhaps, be merged in the question of temperature. Their departure is regulated by the same causes, though, since their food-supply is less uncertain, they linger later in our waters than most of their companion species of the spring.

Material available for the determination of dates.

63. The material for determining the movements of the schools is very unsatisfactory, though perhaps of necessity so. Although many of our correspondents give dates of arrival and departure, these are understood to be merely approximations to the truth. The only series of observations showing the dates of the arrival of menhaden for a period of several successive years is one from the Waquoit weir, and this professes to show nothing except the date at which the fish began to be abundant. In the nature of the case, observations of a more definite nature are impracticable. Since so little that is definite can be recorded, it may be desirable to review the statement, of some of our correspondents, thus putting on record a series of observations all carefully made and many of them extending over a long period of years. In this way the movements of the menhaden at different points upon the coast will be described more accurately and graphically than they could be by any compiled account, however carefully it might be prepared. It is

* Capt. U. S. Treat, of Eastport, Me.

hoped, too, that this course may suggest and elicit fuller observations from persons living in our seaboard towns.

A review of the general movement along the coast.

64. At the approach of settled warm weather the schools make their appearance in the coast waters. They remain in the bays and near the shores until they are warned away by the breath of coming winter. The date of their appearance is earlier in the more southern waters, and the length of their sojourn longer. It is manifestly impracticable to give anything but approximate dates to indicate the time of their movements. In fact, the comparison of two localities, distant apart one or two hundred miles, would indicate very little. When wider ranges are compared there becomes perceptible a proportion in the relations of the general averages. There is always a balance in favor of earlier arrivals at the more southern localities. Thus, it becomes apparent that the first schools appear in Chesapeake Bay in March and April, on the coast of New Jersey in April and early May, and on the south coast of New England in late April and May, off Cape Ann about the middle of May, and in the Gulf of Maine about the latter part of May and the first of June. Returning they leave Maine in late September and October, Massachusetts in October, November, and December, Long Island Sound and vicinity in November and December, Chesapeake Bay in December, and Cape Hatteras in January. Farther to the south they appear to remain more or less constantly throughout the year.

Coast of Florida.

65. In the Saint John's River, Florida, menhaden are abundant throughout the winter. They appear in November clogging the shad-nets. It is not known how far they proceed up the river, but I was unable to learn that they have been taken above Buckley's Bluff, twelve miles above Jacksonville and thirty-six from the mouth of the river; they are particularly numerous at the mouth and in the vicinity of Mayport and Yellow Bluff. That they remain as late as May is well established, and it is the opinion of Mr. Kemps that they are found throughout the summer, the young fish, at least. I have found the grown and half-grown fish abundant at Arlington and Jacksonville in April, 1874 and 1875. After the first of May the opportunities are not favorable for observation, the use of shad-nets being then discontinued. Young fish are seen from May to October, according to Mr. Kemps, in schools over two miles long and extending from shore to shore of the river. Along the coast of Florida, from Cape Canaveral north, the schools of adult fish are said to be common through the winter months.

Coast of Georgia.

66. Mr. Joseph Shepard, of Saint Mary's, Ga., states, on the authority of a Saint Andrew's Bar pilot, that small schools of menhaden are seen in Saint Andrew's Sound during the summer months, coming over

the bar with the flood tide and going out with the ebb, and that the same fish are also seen in large schools in calm weather during the winter months outside the Sea Islands in about seven fathoms of water, and three to four feet below the surface. Mr. Charles C. Leslie, a fish-dealer in Charleston, S. C., informs me that schools of menhaden frequently are seen in the winter off Charleston Harbor; a statement which is confirmed by others, among them Mr. Daniel T. Church, of Rhode Island.

Coast of North Carolina.

67. Mr. A. C. Davis, of Beaufort, N. C., writes that the fat-back first approaches the coast at that place in June, the main body arriving in July from the south, entering the rivers and drifting up with the flood tide and down with the ebb; their appearance is regular and certain, and has never failed, the numbers seeming to be greater every year. They remain in the rivers and inlets throughout the summer, gradually departing toward the close of October and the first of November to the southward. During the season they are constantly coming in at intervals. Those which first arrive are one-quarter to one-half grown, no full-grown fish appearing until later in the season. In bad weather, especially with northern winds, they leave for the sea, returning in moderate weather, with southerly winds.

Mr. A. W. Simpson, jr., of Cape Hatteras light-station, records several interesting facts concerning the movements of the fat-back around that cape. They first make their appearance in June and remain until December; they generally come in to the shore on the northern coast of the cape, running south along the beach and entering the inlets and rivers. In the first of the season they may be seen, in moderate weather, five or six miles at sea, in large schools half a mile in length, apparently floating upon the surface of the water. They always make their appearance from the north and leave the coast by the same route. Some are seen in the sounds and rivers all the year. When the second large run occurs in the fall they appear in immense numbers. This is sometimes in November and in other seasons in December. In 1873 they were first seen on the coast about the 6th of December, and the main body arrived about the 10th of December. Many schools may be seen at one time. They seldom come near the coast in high winds and rough seas, or if they do they swim so low that they are not seen from land. Their appearance is certain and they are about the same in abundance every year at the spring run, but the fall and winter runs vary somewhat, the number in some seasons being very much smaller. Mr. Simpson thinks that the tides do not affect their movements in any respect, except that they prefer to swim against the tide; he has convinced himself, by careful observation, that more enter the inlets on the ebb than on the flood, though they are frequently seen drifting up and down channels with the flood and ebb. The one and two years' fish school by themselves, the young in large schools along the sandy shores. Many fish pass the winter in the inlets and rivers,

but most of them leave the coast by a northern route, the spring runs leaving in October, the fall runs about the middle of January. Some seasons they go to sea in large schools and others they drop away gradually. The first of the spring-runs are usually the smallest. During the summer the large schools are only seen occasionally, though Mr. Simpson thinks that they are on the coast continually. They only come near the outer sea-beach when driven in in October and November by the tailor (*Pomatomus saltatrix*), or blue-fish of the North, and the dog-fish (*Mustelus lævis*).

Coast of Virginia and Chesapeake Bay.

68. According to Mr. Henry Richardson, the alewives are caught in the vicinity of Cape Henry as early as March, though the main body does not come in until June and July. During these months they are constantly passing the Virginia capes and entering Chesapeake Bay, coming from the south.

The Potomac fishermen inform me that they appear in the spring soon after the shad and herring, remaining in the Potomac during the season, where they prove a serious hinderance to the working of the shad seines. Young fish seven inches in length were taken in the lower Potomac at Nanjemoy Reach as late as December 10, 1874, but disappeared after the first heavy frost. The first schools appeared late in March and early in April, 1875, and in 1878 early in March.

At Apateague Island, Accomac County, Virginia, according to Mr. J. L. Anderton, they are first seen swimming northward near the coast in April, the main body arriving in June. Their appearance is regular. They run in-shore on the flood, drifting off with the ebb. In November they are seen making their way toward the south.

In Tangier and Pocomoke Sounds, says Mr. Lawson, they appear about May 1, the fish of different sizes in separate schools; they are found there in quantity throughout the season, the southward migration beginning in August and continuing until the middle of October.

I find a manuscript note by Professor Baird to the effect that they are found in large schools at Cape Charles, Virginia, from April to October, being most numerous on the bay side of the peninsula.

Delaware Bay.

69. Mr. James H. Bell, keeper of Mispillion River light-house, Delaware Bay, states that fish are first seen in those waters early in March, and grow more numerous until about the middle of April, when they are frightened away by the sea-trout. They soon return in increasing numbers until the middle or last of May, after which they begin to disappear in large schools until the first of August, when they again become numerous, and continue so if the weather is mild, when they begin to disappear, working out to sea through the channel. The opinion of Mr. Bell is that after entering the bay they follow the main channel, spread-

ing toward the shores on either side as they advance, until arrested by brackish water. The western shore of the bay is very shallow, the tide near the beach seldom rising above six or seven feet. When the tide is three-quarters flood the fish run in close to land and are caught within twenty yards of the beach; from slack water to first quarter ebb, if it is calm, the water is spotted with the break or ripple, and as the tide recedes they float out with it to deep water. Medium and small fish are found together, not probably in the same schools, but close enough together for the seine to catch fish ranging in length from three to nine inches.

Coast of New Jersey.

70. According to Mr. Albert Morris, menhaden make their appearance in Great Egg Harbor, New Jersey, about May 1, the main body arriving about June, and leaving about the middle of September, the "eastern run" coming along in October or November.

Mr. A. G. Wolf, keeper of Absecom light, Atlantic City, N. J., writes that the appearance of the first schools is regular and takes place in April, the main body coming in July. They come from the returning south by degrees in the fall, beginning in September.

D. E. Foster, of Cape May light-house, states that they appear from the south about April, larger but not so fat as the second arrivals in July, the majority of which are from four to six inches in length. They disappear in November, heading to the north.

Eastern end of Long Island.

71. In the vicinity of Greenport, N. Y., according to Captain Sisson, the first arrivals are in March and April, and according to Mr. Havens, about April 1, while Hawkins Brothers, of Jamesport, put it about the 1st of May. These gentlemen agree that the first schools contain the largest fish; that they are followed for some weeks by other runs, and that the schools leave for the south on the approach of cold weather in October and November.

Mr. Dudley tells me that his steamer usually starts out from Pine Island from the 1st to the 12th of May. She never fails to find fish outside of Montauk Point. The gangs which started out for the season, April 20, 1877, found plenty of fat fish on the first day out.

The late schools of large fish which come upon the Connecticut coast about the 1st of November, and which are supposed to come from the coast of Maine, usually strike across from Watch Hill and Fisher's Island to the Napeague shore, where they sometimes remain several days before their final disappearance from those waters.

Long Island Sound.

72. In the western part of Long Island Sound, at Stratford, according to Mr. Lillingston, they appear about the 1st of May and remain until Octo-

ber, when they leave at once, swimming east. They approach from the east. The largest fish he thinks are found in August. In August and September immense numbers "strike on" and follow up the Housatonic River, and these are invariably poor.

At Milford, Conn., we are informed by Mr. Miles, the first white-fish are seen in April or May, the main body arriving in Long Island Sound in June and July. Sometimes the first fish are the largest. The schools or runs appear to come at intervals of from two to three weeks. The fish come in around Montauk Point, the early fish follow along the Connecticut shore and up the rivers; later in the season they are found off-shore in deep water, though they occasionally work inshore and up the rivers. Their appearance is regular and certain. The schools are mixed as regards size, in the opinion of Mr. Miles. The schools begin to disappear about the 1st of September, passing around Montauk Point to the south, and are all gone by the 1st to the 15th of October.

At Westbrook, according to Captain Stokes, they appear about the middle of May and leave in November in continuous schools, passing around Montauk, bound to the south. In July the schools are the largest.

At Saybrook, says Captain Ingham, the first bony-fish are seen in May, the main body arriving in June. The first are scattering and generally the largest; there are several runs at irregular intervals. The appearance of the fish is regular and certain. They leave in October mostly in a body.

Captain Beebe, of the Cornfield Point light-vessel, writes that the first bony-fish are seen in April, but that these are not the largest. They work along the bays and rivers of the sound, drifting in with the flood and out with the ebb. They leave about the middle of November in a body, passing around Montauk Point to the southward. They ascend the Connecticut above the Shore Line Railway bridge, where they are often followed by the seining gangs belonging to Luce Brothers, of Niantic.

Block Island Sound.

73. Captain John Washington, of Mystic River, Conn., states that the first bony-fish arrive in Block Island Sound early in April, followed by larger schools toward the last of the month, and that they continue to come in during the first half of the summer. They come in around Montauk in large schools, and after passing the outer islands, the large schools break up into smaller ones, which make their way toward the rivers and coves. Their arrival is certain and quite regular, varying but a few days from year to year. They begin to leave in October, and by the last of November are gone. A few stragglers are seen in the Mystic River until the beginning of freezing weather. They swim southward in their fall migration, going faster than when coming north in the spring.

Capt. Jared S. Crandall observes that they first appear in Block Island Sound about May 1, coming from the southward and through the east

end of Long Island Sound, working to the eastward and westward. Their appearance is certain, though their abundance is greater in particular seasons. They leave gradually in November and December, working to the westward after leaving the sound. Small and large are mixed indiscriminately in the schools.

At Block Island, according to Mr. Henry W. Clark, they appear about the 1st of May, and continue running in until about the middle of June. Their appearance is certain but their number variable. They work in and out with the tide, but when they are making a passage the tide does not stop them. They start southward about the middle of October, and continue running for a month.

Mr. Dudley on the schools of Eastern Connecticut.

74. Mr. Dudley, whose vessels ply their nets in both Block Island and Long Island Sounds, tells me that fishing begins at Pine Island from May 1 to May 12, and that for quite a number of years fish have been taken the first day the vessels went out. In 1877 the vessels which started April 20 found plenty of fat fish. Whether the season be hot or cold, the fish come at about the same date. Of late years the first schools have been very fat; immediately followed a run of poorer fish. The run which begins in the middle of April and continues for three or four weeks, is composed of fish yielding from five to seven or eight gallons to the thousand. The next run of fish continues until about the 1st of July. These yield not over four gallons. Then follows a poorer run, averaging two gallons. In 1877 millions of fish have been taken which have not averaged above one quart to the thousand. In 1876 it was much the same, but in July, when the poor fish were most abundant, a few schools made their appearance which yielded ten gallons to the thousand. Of two gangs, fishing side by side, one might make a haul of ten-gallon fish, while the other secured only half-gallon fish. Good fish are usually expected in the fall. In 1876, however, they were few and poor. In 1877 the schools of fat fish made their appearance near Point Judith on the 30th of October.

Narragansett Bay.

75. At Point Judith they come in from the westward, according to the statement of Joseph Whaley. They appear about the 20th of May, and continue to pass, moving eastward, until July. Their arrival is very regular, but sometimes cold weather and easterly winds put them back ten or fifteen days. They begin to leave in October.

Mr. Daniel T. Church, of Tiverton, R. I., states that the menhaden make their appearance in Narragansett Bay about May 1, and continue running in during the season; their arrival in Narragansett Bay for the past eighteen years has been certain, though the time of arrival varies with the weather; they drift with the tide at times, and at others swim against it. No fish are taken in the purse-nets after the cold weather

of the fall, but the gill-nets often take them as late as New Year's. Benjamin Tallman caught 1,600 barrels (400,000) on December 3.*

Martha's Vineyard Sound.

76. At Menemsha Bight the menhaden appear from April 21 to May 10, according to Jason Luce & Co., and swim west. Mr. Marchant, of Edgartown, thinks that they enter the Vineyard Sound from the southwest. It is more than likely that both are right, and the fish enter the sound at either end indifferently. They are seen here in November.

According to Captain Edwards, menhaden come to the vicinity of Wood's Holl, Massachusetts, in May, and remain until October. Captain Hinckley, of the same place, states that they first appear to the westward, striking Montauk Point and following along the coast exactly like the scup, but going more into the bays; they go in more shallow water; he has seen them in 12 feet. A school looks reddish. He has seen a school a mile wide and a mile and a half long. They frequently swim near the surface and make a ripple that can be seen. The first school swims rather deep, but as they become more plenty they can be seen. They generally come in about the 10th of May; in 1871 the first were taken the 21st of April, about three weeks earlier than the average. But they strike off again for about a fortnight before they come regularly.

Capt. Isaiah Spindel, of Wood's Holl, took the first menhaden of the season of 1870, April 23, and the first mackerel at the same time; these were only stragglers, and the best time for catching menhaden that year was about the 10th or 15th of May; in 1871 they came on the 21st of April, when a thousand were caught; a few stragglers had been taken before, perhaps as early as the middle of April. In 1872 no menhaden were seen after the 15th of October.

In the autumn of 1877, which was unusually late and warm, the menhaden lingered on the coast until very late. Vinal Edwards saw many taken, November 28, by the North Truro fishermen, and himself found them at Wood's Holl, December 1.

A very definite idea of the date of appearance of the menhaden in the Vineyard Sound may be gathered from a table given in the Report of the Massachusetts Commissioners of Inland Fisheries for 1871, and here reproduced with additions for convenience of reference.

---

* Report of the U. S. Commissioner of Fish and Fisheries, 1873, p. 184.

77. *Table showing days of first appearance in abundance of menhaden, alewives, scup, and bluefish, at Waquoit weir, since* 1859.

Year.	Menhaden.	Alewives.	Scup.	Blue-fish.
1859	May 6	April 7	May 5	May 16
1860	May 4	April 3	May 2	May 15
1861	May 1	April 1	April 27	May 17
1862	May 6	March 30	May 10	May 13
1863	May 2	March 29	May 8	May 15
1864	May 5	March 28	May 6	May 17
1865	May 1	March 29	May 1	May 16
1866	May 7	April 2	May 8	May 15
1867	May 3	March 28	May 4	May 14
1868	May 15	March 30	May 10	May 19
1869	May 10	March 31	May 7	May 17
1870	May 8	March 28	May 2	May 11
1871	April 21	March 24	April 25	May 24

Irregularities of movements shown by returns of Waquoit weir.

78. The returns of Waquoit weir, which was rented in 1871, by the Massachusetts commissioners of inland fisheries, for the purpose of getting exact statistics on the subject of pound-fishing, show how uncertain and irregular are the movements of the menhaden and their capture in any fixed locality upon the shore. April 21, 1871, 6,000 were taken; April 23, 13,300; May 1, 17,420; May 5, 35,920; May 9, 10,020; May 10, 16,800; May 11, 14,945; May 13, 14,200; May 15, 7,300; May 16, 900; May 18, 1,280; May 19, 1,040; May 20, 7,000; May 22, 6,000; May 23, 26,000; May 24, 2,205; May 25, 780; May 31, 40,300; June 1, 13,260; June 10, 7,540; June 14, 27,300; June 16, 93; June 17, 19. In 1865, from April 21 to May 15, were taken 175,300, and from May 16 to June 2, 35,800; in 1866, between these dates, respectively, 213,730 and 104,780; in 1867, 82,680 and 121,060; in 1868, 45,706 and 79,020; in 1869, 66,680 and 79,030; in 1870, 152,590 and 255,340; in 1871, 136,005 and 99,256.*

South shore of Cape Cod.

79. At Hyannis, Mass., writes Mr. A. F. Lathrop, they appear in May in small numbers, the greatest season of plenty occurring in June. They work along the shore line and into the sounds, bays, and rivers. Their appearance is regular and certain, and they disappear in a body about the 1st of October.

Capt. Reuben C. Kenney, of Nantucket, Mass., states that they appear in the vicinity of that island about the 1st of May, or a little earlier if the season be favorable. They appear to come from the direction of Sandy Hook and the coast of New Jersey. They are most abundant in June and July, and begin their return in October, all disappearing in November.

Capt. Josiah Hardy second, of Chatham, Mass., writes:—"The menhaden seen here are on their route to the eastern shores, coming from

* Report of the Massachusetts Commissioners of Inland Fisheries for 1871, and Report of United States Commissioner of Fish and Fisheries 1871–'72, pp. 174–176.

the west; when they strike Chatham Bay they swim in large schools, coloring the water and followed by numerous sea-birds. They are governed by the winds and weather about showing themselves; in fine moderate southerly weather they come up on top of the water. They have been caught in our bay as early as the 15th of April, but generally not before the 1st of May. I never knew them to fail coming; they generally follow the shores, making their way down the sound by Monomoy Point, and those that get within the point, into the bay, follow the shore to get out on their transit east. There is no difference in their size in the spring, or a very slight one in some schools. In our bays, ponds, and rivers they will head the tide; they come inshore at high water on this coast and at low water keep off the flats and shoal water into the channel or deep water, which is from three to seven fathoms in our bay. I do not think it makes any difference to them about the depth of water; they seem to have a natural instinct, and are just as regular in their course and movements as a flock of sea-fowls; when one is frightened they all start, if one turns all in the school turn, if one goes down all in the school follow. One peculiar trait in them that cannot be accounted for is, that on this coast, as well as on the eastern shore, sometimes for hours there is not a fish to be seen, then all at once they rise to the surface and it is literally full of schools, sometimes turning in a complete circle, at other times all headed one way, then all at once every one has disappeared. The fish pass here (the cape), bound south, in the latter part of September and the first part of October, all moving about the same time. Sometimes in their transit south they find their way into our ponds and creeks and get bothered and belated; they chill very quick in a cold night Their route south is outside of Nantucket Island."

Cape Cod Bay.

80. Mr. David F. Loring, keeper of Highland light, at the northeasternmost point on Cape Cod, states that pogies appear in that vicinity from the last of April to the middle of May, making their appearance in large schools on the surface. After passing by the cape in the spring, they frequently throughout the summer make their appearance in Provincetown Harbor, the bluefish chasing them. They are very seldom seen to school on the ebb tide, but as soon as it turns flood they are seen on top of the water. Mr. Loring states: "I have seen the surface of the water literally covered with schools on the flood tide, while on the ebb there is hardly a fish to be seen. I have seen them under water on the ebb tide, two or three fathoms down, in schools, but they move very slowly until the tide turns flood. Then they school up to the surface of the water and are quicker in their movements. I have seen them in the fall of the year when not schooling, but whether schooling or not they generally play on the surface of the water, except on the ebb tide." They commence to leave the coast about the 1st of October, moving south by

degrees. During the month of November, 1874, the small seining steamers belonging to an oil and guano company in Fall River, Mass., which has a large factory in Boothbay, Me., having left the Maine fishing-grounds after the pogies had left the coast, fell in with large schools just outside of Provincetown Harbor and took 30,000 barrels of them in a short time.

According to Mr. Heman S. Dill, light-keeper on Billingsgate Island, pogies appear in Barnstable Bay about May 10, not varying over four or five days from year to year.

Vicinity of Cape Ann.

81. At Marblehead, Mass., we are informed by Mr. Simeon Dodge, the fish appear about May 9, a larger body appearing in July; their course is northward, their appearance certain. Their favorite locality is at the mouths of fresh-water streams, moving up the creeks with the flood and and down with the ebb. They take their departure in a body about the last of October.

Capt. F. J. Babson, of Gloucester, Mass., states that the appearance of this fish for the past thirty years has been regular and certain. They first appear in Massachusetts Bay about the 15th of May, and are present in the greatest numbers a month later. When in deep water they are not affected perceptibly by the tide, but when near the shore run in and out of the rivers and creeks with the tide. They swim low during easterly winds, but in warm and pleasant weather play at the surface, They begin to leave the coast about October 1, and by the last of the month are all gone.

Gulf of Maine.

82. According to Judson Tarr & Co., they come on the coast of Maine about the 1st of June, though they are not plenty until June 20; they continue coming until July. They follow the shore coming and going, and their appearance is certain; they have never been known to fail. They leave the coast about October 1, on the approach of cold weather.

Mr. J. Washburne, jr., of Portland, Me., states that pogies appear in that vicinity June 10 or 15. They come in two schools; the first, which are small, usually come about ten days before the second school. They remain during the summer and work in shore on the flood tide and out on the ebb. They leave for the South about October 1; in 1874, some were taken November 4.

Mr. G. B. Kenniston, of Boothbay, Me., who is largely engaged in the menhaden fisheries, thus gives the result of his personal observations: "The pogies are first seen about May 20 in occasional schools. The main body arrives about June 20, which, passing to the eastward, is followed by others continually for about thirty days longer. There is considerable difference in the size of the fish caught. At times, mixed sizes are taken at the same set. Usually those arriving at different periods differ

in size, the larger may come sooner or later; nothing certain is known as regards this. After rounding Cape Cod, some touch the coast in the vicinity of Gloucester, Mass., but by far the larger portion it appears keep off shore, and near it anywhere from Cape Elizabeth to Monhegan. The main body of these fish continue to pass toward the east till about the 20th of July, when that impetus seems to be checked, and for thirty or forty days their movements are seemingly local. Then they begin their return to the west, and continue to repass until in October. The last bodies are urgent in their westward course. Their appearance is regular, and they have never been known to fail. The temperature of the air affects them; they will not 'show' or come to the surface when cold north or east winds prevail."

Boardman and Atkins state that the latest date at which menhaden have been observed on the western coast of Maine, between Cape Elizabeth and Pemaquid, is October 25, and the period of greatest abundance about the last of July or the first of August, although for several weeks preceding and following that date, there is little variation in their number. Since the publication of his report Mr. Atkins has observed small menhaden as late as December in the vicinity of Bucksport.

Mr. Benjamin F. Brightman, of Round Pond, Me., also largely interested in the fisheries, states that the first fish make their appearance about the 1st of June, though usually scattering. Seining begins about the 15th; the fish are poor then and rather smaller than those taken in August and September, when the smacks go off shore from five to thirty miles to get larger and fatter fish. Seining begins about the 15th of June, and continues until the 15th of October. They are most abundant and easily seen on a warm, sunshiny day. The fish start to go west about the middle of September, and continue going until the last of October.

Mr. John Grant, keeper of Matinicus Rock light-station, writes that they arrive about the 1st of June, the larger body from the middle to the last of June, the last school being much the largest and fattest. There are commonly several schools at irregular intervals. A favorite playing-ground is between Seguin Island, and Matinicus Rock, and in the bays and mouths of rivers between those two points. The fish leave about the middle of October in a body.

On the eastern side of Penobscot Bay near Brooklin, according to Messrs. J. C. Condon and R. A. Friend, pogies come in from the 10th to the 15th of June, and leave by degrees after the 1st of October. They are most abundant in June and July.

In the same vicinity, according to Mr. Z. D. Norton, the first menhaden seen are scattering individuals that are caught in gill-nets and wears in May, often as early as the middle of the month. The schools do not appear until the middle of June, on an average. They leave in September commonly. In Bluehill Bay they are sometimes known to stay as late as October.

Mr. William H. Sargent, of Castine, Me., has known them to come in as early as May 25, and has seen them in November.

Eastward from this point the stay of the menhaden is materially shortened up. At Jonesport, according to Mr. George R. Allen, it is almost confined to the month of August, scattering ones being taken in July. In Passamaquoddy Bay and vicinity menhaden are now rarely seen. Formerly they were found in all these waters in August.*

Mr. Maddocks on the Maine schools.

83. Mr. Maddocks states: "Its appearance on the coast of Maine is from about June 1, to October 1. The date of coming rarely varies more than five days; that of departure is sometimes delayed until October 15, if the weather continues mild and calm. It usually disappears from the surface during the continuance of cold northerly winds; and even in favorable weather alternately rises and sinks during the day, the morning and evening being the time of most general appearance. The first straggling comers are generally discovered on the 'outer grounds,' so called, some forty miles off shore. The numbers increase with the advance of the season, the fish gathering in schools or bunches from the size of a dining table to ten acres large, and fifty of these being frequently visible at once from the mast-head. In these bunches the fish extend from the surface two or three fathoms deep, more or less, as far at least as can be seen, in a compact mass, either lying perfectly still or moving slowly with their heads all pointed one way as if intently gazing upon an object before them."† And again: "It is certain that the disapparance of the menhaden from the Maine coast in the autumn is accomplished by a movement of vast numbers (not necessarily the whole or even the greater number) to the west and south along the shore. The withdrawal is nearly simultaneous, but in a body so immense that the vanguard reaches Cape Cod before the rear has left the Maine waters. Our fishermen follow the retreating army as far as Cape Cod and Sandy Hook, and make large captures."

13.—MIGRATIONS.

Migrations of fishes and their causes.

84. It was formerly believed that all seasonal migration was directed toward and from the equator, but zoologists of the present day recognize another kind of migration quite as important although not usually so extended. At the approach of the hot season in subtropical climates the birds seek a cooler temperature, either by flying northward or by ascending the high mountains. In like manner the fishes of any region may find water of suitable warmth by moving north or south along

* Goodale & Atkins, op. cit., p. 4.

† The Menhaden Fishery of Maine, p. 4.

the shores of the continent, or by changing to waters of less or greater depth. The former may be called equatorial, the latter bathic migration.

Bathic migration is the most common. The cod family, the halibut, and flounders, the scuppaug, tautog, sea bass, and sculpins, are well known examples. The cod prefers a temperature of from 35° to 42° F. and this it secures in a temperate climate, such as that of Southern New England by remaining on the off-shore banks in 15 to 30 fathoms of water, coming near the shore in winter. On the coasts of Labrador, Newfoundland, Nova Scotia and Eastern Maine they are near the shore in summer and in deep water in winter. In Norway the fish are caught to some extent in the fiords in the summer season, though more in winter. In summer they still remain on the off-shore banks. The halibut moves up and down on the sides of the great oceanic banks and the continental slopes, with the seasonal changes of temperature. In summer they are abundant in the shallows of South Greenland, while in winter they are in deep water. On the coast of Massachusetts they come near the shores only in the dead of winter, though abundant in summer on the edges of the outside banks in 80 to 300 fathoms of water. The sand dabs (*Hippoglossoides dentatus*) are abundant in July in water of 60 and 80 fathoms ten miles off Cape Ann; in the middle of winter they swarm upon the sand flats in two or three fathoms depth.

The Spanish mackerel, the bonito, and the tunnies are good examples of nomadic species. In summer they throng our northern waters; in winter they are under the tropics.

Others, like the sea-herring, appear to migrate in two ways. Their movements are, approximately, both parallel with and vertical to the coast line; that is to say, they secure changes of temperature both by leaving the upper strata of the ocean and by moving toward and from the equator. The researches of Boeck in Norway, show that the schools approach the coast by gullies or submarine valleys from the oceanic depths. Such is doubtless the case on our own coast, in their earliest approaches, though having reached the shallows near the shore, the schools range along great stretches of coast line. Since fishes have no restrictions upon their movements except those of food and temperature, all active species must traverse areas of many hundreds of miles during the year.

The tendency of all the researches made during the past few years has been to confirm the views advanced by Professor Baird in an unpublished letter written in 1873 to the Hon. Hamilton Fish, Secretary of State.

"The question in regard to the migration of fishes is one that has attracted the attention of both fishermen and naturalists for many years past, and a great deal of eloquence has been expended by Pennant and other writers, in their history of the movement of herring and other species.

"For many years it was considered beyond question that the sea herring, having their homes in the northern seas, were in the habit of

prosecuting extensive journeys, in the course of which they successively visited the shores of Europe and of America, penetrating into their bays and sounds, and returning afterwards to the point from which they started; the adults decimated by the predaceous fishes and their capture by man, but their numbers kept up by the progeny, the result of their spawning operations, for which purpose it was supposed their journeys were initiated.

"In the same manner the shad and the fresh-water herring of the American coast were supposed to start in the late winter along the southern coast of the United States, in a huge column, the herring first, and afterward the shad, first entering the Saint John's River in Florida, and while passing up the coast sending off detachments into all the principal rivers, and finally stopping in about the latitude of the mouth of the Gulf of Saint Lawrence.

"This theory is at present almost entirely abandoned, and there is reason to believe that after the herring and shad have spawned in the rivers they proceed to sea, and spend the period until their next anadromous movement in the immediate vicinity of the mouths of the rivers, where they are followed in due course of time by their young. This is illustrated by the fact that fish of nearly every prominent river show some peculiarities by which both the fish-dealer and the naturalist can distinguish them; the difference not being sufficient to constitute a specific rank, but such as to mark them as local races. Numerous captures, too, in gill-nets and otherwise, off the northern coast, during the period when they should be gathered together in the southern waters, prove that a portion at least remain. It is difficult to imagine how a shad or a river herring, spawned in the Saint Lawrence River or any northern stream, could avoid entering a more southern river, if in its vicinity; but if any fact has been well established of late years in the history of the fishes, it is that the anadromous fish, or such as run up the rivers from the sea to spawn, will return if possible to the river in which they first saw the light. So true is this, that where there may be two or three rivers entering the sea in close proximity, which have become destitute of shad or herring in consequence of long-continued obstructions, and the central one only has been restocked by artificial means, the fish, year by year, will enter that stream, while those adjacent on either side will continue as barren of fish as before."

The influence of ocean temperature on the movements of menhaden.

85. The influence of ocean temperature on the menhaden is not at all well understood, and I can here record only crude generalizations founded upon very unsatisfactory data. I have before me three tables showing the variations of temperature, by monthly means, for Key West, Fla.; Jacksonville, Fla.; Savannah, Ga.; Charleston, S. C.; Wilmington, N. C.; Norfolk, Va.; Baltimore, Md.; New York City; New London, Conn.; Wood's Holl, Mass.; Portland, Me.; and Eastport, Me. Table I shows

the monthly means of surface temperature; Table II, of temperature at the bottom near the shore; and Table III, the average means of the surface and bottom temperatures. The observations were all made at 3 p. m., and are continuous from March 1, 1876, to March 1, 1877. These are reproduced in Appendix F. There is, also, a table of the daily observations of temperature at the surface at the same stations. A study of these tables, which, for convenience, were mapped out in curves upon section paper, affords some interesting results.

Minimum limits of temperature and the dates of appearance and disappearance of the schools.—The monthly mean of surface temperatures at Eastport is greatest in September, when it is 50°.6, while the highest daily observation is 51°.5. The menhaden do not visit Eastport in midsummer. Let us divide the monthly averages for May, at Portland, into quarterly periods. The average for May 16–23 is 47°.1; for May 24–31 is 51°. The quarter-month averages for October are 53°.8, 50°.8, 47°.9, 48°.8.

The schools of menhaden arrive in Eastern Maine late in May and early in June, and depart, usually, before the middle of October.

At Wood's Holl the quarter-month averages for May, as taken by the Signal Service observer, are 48°.2, 49°.6, 53°.1, and 57°.6, approximately, or the monthly average, 52°.3. These observations are made in the Great Harbor, at the railroad-wharf. Another series of observations, made by Captain Edwards, for the Light-House Board, in the Little Harbor, are believed to indicate more nearly the temperature of the Vineyard Sound. These, however, are only for bottom. The difference between the monthly mean of bottom temperatures for May, at the two stations, is almost two degrees (1°.8), the figures being 51°.5 for Great Harbor, for Little Harbor 53°.3. It does not seem assuming too much to place the quarter-month average for the first half of May at 50° and 51°.4. For November the Great Harbor quarter-month means are 51°, 51°, 47°.7, 43°.3.

The menhaden strike into Vineyard Sound early in May or late in April, and linger until November, and even December.

At New London the quarter-monthly averages for the last half of April and the first half of May are 49°, 48°.5, 52°.5, 54°.5; for late October, 55°.2, 54°.9; for November, 53°.5, 51°.1, 48°.1, 46°.1.

The fish come on the eastern coast of Connecticut late in April, and are frequently taken as late as the middle of November. The temperatures of New London suggest that there may be something in error in the Wood's Holl observations in so far as they are supposed to indicate the temperature of the ocean in its immediate vicinity. The periods of appearance and disappearance at Waquoit and Menemsha, in the Vineyard Sound, agree nearly with those of Eastern Connecticut.

The temperature of the Chesapeake must be studied from the observations made at Baltimore and Norfolk. At the latter place the April means are 52°, 56°.5, 61°.2, 60°; the November means, 59°, 54°.6, 53°.5,

48°.5; at the former for April, 45°.6, 50°, 54°.5, 55°.7; for November, 54°.2, 52°.1, 50°, 47°. At Norfolk the averages for the last half of March are 48° and 50°.

The movements of the menhaden in other waters have not been very carefully observed, but we know that they enter the Potomac late in March and early in April, and that they linger till the last part of November. In 1874 the young menhaden lingered in the Lower Potomac until the middle of December. In 1876 the average for December surface temperature at Norfolk was 36°.8, for bottom temperature 36°.4. In 1874 the surface average for December at Norfolk was 43°, or 6°.4 higher than in 1876, the year from which our tables of observations are made up. The average for Norfolk surface temperature in November was, in 1876, 53°.4, in 1874, 55°.1 or 1°.7 higher. It is quite probable that in 1874 the water of the Lower Potomac did not become colder than 50° until December.

At Wilmington the monthly means of bottom temperature in 1876 and 1877 were for December, 43°.1, January, 43°, February, 48°.5; in 1874 and 1875, December, 48°.1, January, 43°.8, February, 45°.5. December, 1876, was unusually cold, the mean temperature of the air being 46°.3, against 59°.1 for the same month in 1874. January and February of 1874 were relatively cold, their air temperature being 48°.1 and 53°.1, against 57°.1 and 52°.5 in 1876. The surface quarter-month averages for the last half of February, 1877, are 49°.1, 50°.5; for the first half of March, 1876, 52°.6, 57°; for late November and early December, 1876, 57°.1, 53°6, 46°.6, 45°.3.

No observations have been made upon the movements of the menhaden at Wilmington. At Beaufort, 30 miles farther north, they appear to be absent during the winter.

It is much to be regretted that there are no temperature observations from Cape Hatteras. The relations of this locality to the Gulf Stream are peculiar, and corresponding peculiarities in the temperatures no doubt exist. The hundred fathom curve is distant about 40 miles from the point of the cape, and the average summer limits of the Gulf Stream, as laid down upon the British Admiralty charts, extend nearly into this curve. The observations made at Wilmington, situated as it is in a bend of the coast, at least 100 miles from the summer limits of the Gulf Stream, and at the mouth of a river which rises 200 miles away in the elevated central portion of North Carolina, can hardly be taken as criteria of the temperatures of Cape Hatteras. This is still more unfortunate from the fact that the movements of the menhaden, bluefish, "sea-trout," and other warm-water species are very peculiar at this point. It will be strange if the monthly mean of water temperature for Cape Hatteras in December, and perhaps January, does not prove to be more than 50°.

Savannah is at least 120 miles from the Gulf Stream, and its means for December and January, 1876–1877, as well as those of Charleston, are below 50°. Charleston water appears to be uniformly warmest. In

1874, December in Charleston averaged 48°.8; in 1875, January averaged 50°.2.

The movements of the menhaden in this region have not been observed, but since in the north it is not more hardy than the shad, and since the shad do not venture into the Georgia and Carolina rivers in December, it is safe to predict that the habits of the menhaden are similar.

Jacksonville, Fla., is the only point on the east coast from which there are observations showing a temperature unformily above 51°, and here the menhaden remain throughout the winter.

Maximum limits of temperature.—On the coast of Eastern Maine we are told that the menhaden schools keep passing to the eastward until about the middle of July, when their impetus is apparently checked and their movements for thirty or forty days seem to be local only. During this period the temperature at Portland ranges from 60° to 70°, this being the height of mid-summer. The monthly means for July and August, 1876, were 66°.7 and 63°.9. The same months at New London are placed at 73° and 73°.3; at Norfolk, 84°.1 and 78°.3. Wilmington, Charleston, and Savannah do not range much above Norfolk; June, July, and August at Jacksonville average above 85°, and we have no satisfactory evidence that the menhaden are seen there in mid-summer. At Key West the lowest monthly mean is December, at 66°.4, in an unusually cold winter.

Preferred range of temperature.—These facts appear to indicate that under ordinary circumstances the menhaden prefers a temperature of 60° to 70° Fahrenheit. When the rising temperature of spring has passed the limit of 50° to 51° the fish are certain to appear, and when the falling temperature of autumn reaches that point their departure is equally sure, though a few individuals may linger in waters not congenial to them. The opposite limit seems to be marked by the line of 80° or perhaps 75°. An easterly or northerly wind, lowering temporarily the surface temperature, causes the schools to sink below the surface, as is shown in paragraph 95. The chill of night also drives them down.

These conclusions are not to be regarded as final. The movements of the fish about Cape Hatteras are very puzzling and need to be interpreted by a series of careful temperature observations.

It is a well-established fact that the summer of 1877 was not so warm as that of the preceding year. It is also known that the catch of menhaden in Maine for that year was much smaller than in 1876, when it was unusually large. There may be a connection between these circumstances, though the observations of water temperatures at my disposal are not sufficient to warrant decided generalization. The means for the summer months of 1876 were, at Eastport, 45°.5; at Portland, 57°.9; at Wood's Holl, 70°.4; at New London, 68°; at Norfolk, 78°.7. The corresponding means for 1877 were, at Eastport, 42°.8; Portland, 57°.6; Wood's Holl, 67°.7; New London, 66°.9; and Norfolk, 77°.2. The summer of

1877 was then colder than that of 1876 by 2°.7 at Eastport; by 0°.3 at Portland; by 2°.7 at Wood's Holl; by 1°.1 at New London; and by 1°.5 at Norfolk. July, 1877, was colder than July, 1876, at Eastport by 2°.8; at Portland by 2°.2; at Wood's Holl by 5°.9; at New London by 1°.2. August, 1877, was colder than August, 1876, at Eastport by 0°.3; at Portland by 0°.6; at Wood's Holl by 0°.9; at New London by 3°.1. September and October of 1877 were warmer than the corresponding months of 1876 at Portland, and this agrees with the fact that the catch of menhaden in Maine was entirely made in the fall months.

General discussion as to the winter habits of summer fishes.

86. The relations of the temperature of the water to the movements of the menhaden schools having been studied, a new question is at once suggested. When the schools disappear from our coast, driven by falling temperature, where do they go? The answer must be in the form of a theory, for no one has seen them during their winter absence; at least no one has been able to identify the New England and Middle States fishes after their departure in the autumn. It is evident that there are but three courses open to our coast fishes when it becomes necessary for them to leave inshore—

(1.) They may swim out to sea until they find a stratum of water corresponding in temperature to that frequented by them during their summer sojourn on our coast.

(2.) They may swim southward until they find water of the required warmth.

(3.) They may descend into the abyssal depths of the ocean, there to remain for a season in partial or total torpidity.

The last of these theories is the least plausible, from the fact that it necessitates the greatest change in habits. The susceptibility of the menhaden to slight changes of temperature has been pointed out. Hibernation in the oceanic depths involves a change to a temperature 10° to 25° colder than that preferred by them in summer, as well as other important changes in respect to specific gravity and pressure.

The theory of hibernation discussed with special reference to the habits of the mackerel.

87. The hibernation theory is a favorite one with the fishermen of the British Provinces, and has recently received strong support from Professor Hind, in his treatise on the fisheries of North America. His arguments refer to the mackerel, although the scup, tautog, and herring are included by implication. He refers to the appearance of the mackerel "with scales on their eyes and blind," and suggests that the winter sleep of fishes is probably much more general than is usually supposed. He takes the position that there are only two alternatives possibly open to fishes which cannot live in cold water. They must migrate south or

hibernate. His arguments naturally fall into two categories—those against migration and those in favor of hibernation. Those in favor of hibernation may be summed up as (1) the testimony of fishermen and travelers; (2) the quoted opinions of theorizers; (3) the alleged hibernations of other fishes; and (4) peculiarities in early and late fish.

(1.) The statements of one M. Pleville le Peley, "an eye-witness," are quoted both from Lacepede and H. de la Blanchere. M. le Peley gravely states that he had observed about the coasts of Hudson's Bay "the mud at the bottom of the small clear hollows incrusted with ice round their coasts, entirely bristled over by the tails of mackerel imbedded in it nearly three parts of their length,"* and again "affirms having seen in the middle of winter, in deep muddy bottoms, myriads of mackerel, packed close one against the other, with one-half of the body plunged in the mud, where they remained during the winter. As soon as spring came they aroused themselves from their torpor, and appeared always on the same day on the same coast at the surface of the sea, and repaired to favorable spots to spawn."† The absurdity of these statements renders it unnecessary to criticise them. The other testimony is less definite. A Newfoundland fisherman remembers to have heard his father say that forty years before "he had often seen mackerel in White Bay come on shore like squid, with scales on their eyes and blind, about Christmas."‡ And, again, a statement quoted from the Rev. John Ambrose, that "mackerel have been brought up from the muddy bottoms of some of our outer coves by persons spearing for eels through the ice,"§ which statement is not supported by the personal evidence of Mr. Ambrose, being merely a hearsay story. And this is all.

Professor Hind, in Part II of the same work‖ remarks confidently: "That the mackerel spends the winter months in a torpid condition near to the locality where the schools first show themselves on the coast has already been adverted to," and again refers to "the fact, already noticed, that it is taken in winter from muddy bottoms." I submit that no such fact has been established and that Professor Hind's generalizations are without foundation. There is much better evidence to prove that swallows hibernate in the mud of ponds, a theory which has had numerous advocates since the time of Gilbert White, of Selborne.

(2.) Professor Hind first quotes from "La Peche et Les Poissons" of M. H. de la Blanchere. The statement, printed as it is in a single paragraph instead of two and not given in full, conveys the impression that M. de la Blanchere indorses the views of Pleville le Peley, already quoted. On the contrary, he states explicitly: "The question of the annual and

* Hind, *op. cit.*, Part II, p. 10, note.

† Part I, p. 78.

‡ Part I, p. 78.

§ Observations on the Fishing Grounds and Fish of St. Margaret's Bay, N. S., by Rev. John Ambrose. <Proceedings and Transactions of the Nova Scotian Institute of Natural Sciences, 1866-'67, quoted by Hind, *op. cit.*, Part I, p. 79.

‖ P. 10.

regular appearance and disappearance of this fish is still unsolved." He then proceeds to contrast with M. le Peley's views those of Duhamel de Monceau, Anderson and others, who represented that the mackerel pass the winter in the northern seas, and in spring, beginning their migrations, pass southward visiting first Iceland, then Jutland, then Scotland, and Ireland, and the coasts of Continental Europe, in autumn assembling together for a return to the polar regions. Then he quotes Pleville le Peley, and remarks: "This theory associates the mackerel with many other sedentary fishes which pass the winter at the bottom of the sea, stupefied by the cold into a kind of lethargy, and would serve to explain why, in October, young mackerel of 10 and 15 millimeters are taken, why in winter others of larger size are taken, not with a line, but with nets, which entangle those which had not already buried themselves in the mud or the sand."*

Another quotation is made† from Shaw's "General Zoology, or Systematic Natural History," published in 1803. Professor Hind says that "the four disputed points in relation to the natural history of this fish are there asserted, namely, its local habits, its torpidity during hibernation, the film over the eye, and the fact of its being partly imbedded in the soft mud or sand during its winter sleep."

I admit that Shaw asserts the presence of a film over the eye. He does not, however, even give the theory of hibernation his personal indorsement, but remarking that the long migration of the mackerel and herring seems at present to be called in question, continues, "It is thought more probable that the shoals which appear in such abundance round the more temperate European coasts, in reality reside during the winter at no very great distance, immersing themselves in the soft bottom, and remaining in a state of torpidity, from which they are awakened by the warmth of the returning spring, and gradually recover their former activity."

Even if Shaw could fairly be quoted as a supporter of this theory, his opinion is of little value. He was not a naturalist, but a bookmaker, and his compilations are acknowledged to be inaccurate.‡

The opinions of Dr. Bernard Gilpin and the Rev. John Ambrose, two excellent Nova Scotian observers, are quoted,§ though with no apparent reason, for the latter remarks only that "it is the opinion of some" that the third run of mackerel, which takes place at St. Margaret's Bay about the first of August, are not returning from the Gulf of Saint Lawrence, but from sea, and "it may be that a portion of the immense schools passing eastwardly in the spring strike off to some favorite bank

* Nouveau Dictionnaire Général des Peches, &c., par H. de la Blanchere. Paris, 1868, p. 183, article *Maquereau*.

† Hind, *op. cit.*, Part II, p. 10.

‡ See a criticism upon Shaw's General Zoology in Gill's Arrangement of the Families of Fishes, &c., 1872, pp. 40, 41.

§ Part I, p. 79.

outside to deposit the spawn. Or there may be a sort that never go as far east or west as the others, but winter along our shores," &c.; while Dr. Gilpin expressly remarks that though the *asserted torpidity and blindness* favor the idea of hibernation, he does not think that we have yet sufficient proof to assert them as facts.

The authorities quoted in support of the hibernation theory do not in fact support it, and the testimony cited by Professor Hind is merely tradition and popular opinion, some obtained directly, the remainder at second-hand.

(3.) Still another set of arguments is based upon the supposed hibernating habits of other species of fishes. Professor Hind remarks: "In seas which are not ice-encumbered the winter torpidity (of the mackerel) may be of very short duration; in ice-encumbered seas it may extend over several months. In this particular the mackerel resembles the sturgeon of the Caspian Sea, whose torpidity during winter is well known, and this winter sleep is not confined to these fish, but is probably much more general than is usually supposed."*

Here we have a definite statement. The mackerel hibernate, and the winter sleep is not confined to the mackerel.

The only hibernation which is definitely known to occur among fishes takes place in the fresh-water lakes and streams of cold regions. The fish are driven by cold into the deeper waters, and there remain in a state of torpor proportionate in degree to the amount of cold which they experience. They may even be frozen up in the midst of a mass of ice and recover their vitality when the ice is melted.†

In warm regions an analogous phenomenon takes place which has been called æstivation. When the lakes and streams are dried up by the heat the fish seek refuge in the deepest pools, and when these too are dry they bury themselves in the mud at the bottom and remain torpid until the rainy season refills the reservoirs and revives them.

Fishes in the extreme north doubtless undergo similar experiences, though I am not aware that any record of such a phenomenon has ever been published.

Hibernation and æstivation do not appear to be in any case voluntary acts. The fish do not become torpid of their own volition. They avoid it as long as they can, and only succumb when they are deprived of means of escape. They never become torpid when there are greater depths to which they can retreat.‡

---

* Part II, p. 11.

† Mr. Milner had a mud-minnow (*Umbra limi*) which was frozen in solid ice in the middle of an aquarium globe three or four times, and each time recovered its vitality upon thawing out.

‡ "A curious phenomenon in Indian fresh waters, and one which has never been satisfactorily explained, is the sudden appearance of healthy adult fishes after a heavy fall of rain, and in localities which for months previously had been dry. When pieces of water inhabited by fish yearly dry up, what becomes of them? On January 18, 1869, when examining this question, I was taken to a tank of perhaps an acre in extent, but

(4.) Professor Hind lays much stress upon the presence of a "film" over the eyes of the spring and autumn mackerel and upon their alleged capture in winter in the waters of the Dominion, and also quotes arguments for hibernation based upon the resemblance of the mackerel to the batrachians (which are known to be capable of hibernation) in color, and upon its resemblance to embryonic forms of other fishes which is supposed to "prove him low in the scale of intelligence."* To the latter it is needless to refer. The so-called "film" on the eye is not peculiar to the mackerel. Many fishes, such as the shad, the alewife, the menhaden, the bluefish, the mullet, the lake whitefish, and various cyprinoid fishes have a thick, rough membrane covering the anterior and posterior angles of the orbits narrowing the opening to the form of an ellipse with a vertical major axis. This possibly becomes somewhat more opaque in seasons of decreased activity. It

---

which was then almost dry, having only about four inches of water in its center, while its circumference was sufficiently dried to walk upon. The soil was a thick and consistent bluish clay, from which, and not nearer than thirty paces to the water, five live fish were extracted from at least two feet below the surface of the mud. They consisted of two of *Ophiocephalus punctatus* and three of the *Rhynchobdella aculeata*. All were very lively and not in the slightest degree torpid. They were covered over with a thick adherent slime. Among the specimens of fish in the Calcutta museum is one of the *Amphipnous cuchia*, which was dug up some feet below the surface of the mud when sinking the foundation for a bridge. If when the water failed fish invariably died, the tank would be depopulated the succeeding year unless a fresh supply was obtained from some other source, while the distance from other pieces of water at which they reappear excludes, in many instances, the possibility of migration, which must always, to a certain extent, be regulated by distance, time, and other local circumstances. Some species, especially "compound breathers," are unable to live in liquid mud, which they cannot employ for purposes of aquatic respiration.

"The practical question is, whether, when food and water fail, some fish do not æstivate until the return of a more favorable season. Natives of India assert that they do thus become torpid in the mud. As the water in tanks becomes low, the fishes congregate together in holes and places in which some still remains, where they may be frequently seen in numbers huddled together with only sufficient water to cover their dorsal fins.

"If disturbed they dive down into the thick mud, so that a net is often found ineffectual to take them. The plan employed to capture them is for the fisherman to leave the net in the water, and to walk about in the surrounding thick mud; in time they come to the surface to breathe, and fall an easy prey.

"As the water gradually evaporates, the fishes become more and more sluggish, and finally there is every reason to believe that some at least bury themselves in the soft mud, and in a state of torpidity await the return of the yearly rains. In Ceylon, Mr. Whiting, the chief officer of the western province, informed Sir Emerson Tennent that he had accidentally been twice present when the villagers had been engaged in digging up fish. The ground was firm and hard, and "as the men flung out lumps of it with a spade, they fell to pieces, disclosing fish from 9 to 12 inches long, which were full-grown and healthy, and jumped on the bank when exposed to light. Many other animals which possess a higher vitality than fish æstivate during the hot months, as *Batrachians*, the *Emys*, the *Lepidosiren annectens*, and some of the *crocodiles*. Mollusks and land-snails are commonly found in this state during the hot and dry months. (Day's Fresh-water Fish of India, p. 28.)

* Part I, p. 79.

never has been observed to cover the whole eye. Until the fact has been established that "a skin forms over the eye in winter" it is quite unnecessary to propose the theory that such a skin "is probably designed to protect that organ from the attacks of the numerous parasitical crustaceans and leeches which infest the external portions of the bodies of fishes, and are also found internally, as in the gills of codfish"*

Criticism of the argument based upon the presence of mackerel in northern waters late in the season.

A number of instances are cited to prove that the mackerel schools remain on the coast of the Dominion throughout the winter season. If this can be well established it is a very strong argument in favor of hibernation. Let us analyze the testimony.

Dr. Gilpin is quoted to the effect that during some seasons they linger on the Nova Scotian coast until December, and allusion is made to a mackerel obtained by him at Halifax, October 27, 1875.†

Mr. John Rice remembers that his father used often to speak of mackerel "coming on shore like squid with scales on their eyes and blind about Christmas," about 40 years ago.‡

Mr. Jabez Tilley states that they have been taken in November in Trinity Bay.

Professor Hind also states that they are to be found on the whole coast from Quirpon to Cape Spear during November and December. He gives no authority for this statement, and it is to be inferred that it is founded upon personal observation.

Then there is the vague statement of Mr. Ambrose, already quoted, that mackerel have been speared on muddy bottoms under the ice.

Now this testimony does not, by any means, tend to prove that the mackerel remain near the coast in winter.

In the first place there is no satisfactory proof of their occurrence later than October 25, since that is the only evidence fortified by a memorandum of date, and the memories of fishermen are not more certain than those of other men.

In the second place it is not impossible that mackerel linger in these waters until November or even December in the case of a very warm autumn. The temperature necessary for the menhaden cannot be many degrees below 50°, while the mackerel appears to endure a temperature of 41° or less. Menhaden linger in Maine waters till November and in Massachusetts Bay and the Vineyard Sound till December.

Finally, the undoubted capture of many individuals in winter on the coast of Newfoundland would by no means prove that the great schools were there throughout the season. Disabled, blind, or diseased individ-

* Hind, *op. cit.*, Part II, p. 11.

† Part I, p. 79.

‡ Part I, p. 78.

uals would naturally be unable to accompany the departing schools. Such fish would naturally grovel on the bottom in a helpless state and might easily become impaled on the eel-spears, or might be thrown on shore by the waves, as the Newfoundland fishermen relate. Even healthy fishes might occasionally be accidentally detained. Mr. Peter Sinclair a well-known fisherman of Gloucester, stated to Professor Baird that some years ago a school of mackerel were detained all winter in a small river in Nova Scotia, and were speared out of the mud. This is doubtless hearsay testimony and is given for what it is worth. I do not doubt that there have been individual cases of this kind, but I maintain that no generalization should be founded upon them.

The theory of extended migration discussed with reference to the habits of the mackerel.

88. The preceding paragraph is devoted to the refutation of the idea that sea-fish hibernate. This is regarded as the least probable of the three hypotheses stated in paragraph 85. In paragraph 84 it is stated that the sea-herring and many other fishes have two kinds of migrations: one bathic, or from and toward the surface; the other littoral, or coastwise. Now, in some species the former is most extended; in others, the latter. The anadromous species very probably strike directly out to sea without coasting to any great degree, while others, of which the mackerel is a fair type, undoubtedly make extensive coastwise migrations, though their bathic migrations may, without any inconsistency, be quite as great as those of the species which range less.

Upon this point I cannot do better than to quote from a manuscript letter from Professor Baird to the Hon. Hamilton Fish, Secretary of State, dated July 21, 1873. Having expressed the views concerning the migration of the herring and shad already quoted in paragraph 84, he continues:

"The fish of the mackerel family form a marked exception to this rule. While the herring and shad generally swim low in the water, their presence being seldom indicated at the surface, the mackerel swim near the surface sometimes far out to sea, and their movements can be readily followed. The North American species consist of fish which as certainly, for the most part at least, have a migration along our coast northward in spring and south in autumn, as that of the ordinary pleasure-seekers, and their habit of schooling on the surface of the water enables us to determine this fact with great precision. * * * Whatever may be the theories of others on the subject, the American mackerel-fisher knows perfectly well that in the spring he will find the schools of mackerel off Cape Henry, and that he can follow them northward day by day as they move in countless myriads on to the coast of Maine and Nova Scotia."

It is difficult to estimate to what extent the advocates of the hibernation theory have been influenced by patriotic motives in their efforts

to prove that the mackerel remain in the waters of the Dominion of Canada throughout the entire year. It is certain that all recent treatises on ichthyology by Canadian writers have appeared in the form of campaign documents apparently intended to influence the decisions of diplomatic commissions.

I am by no means prepared to maintain that mackerel do not pass the winter in the American domain of Her Imperial Majesty. It seems important, however, that the subject of the migration of fishes should be restored to its proper position as a question of abstract scientific importance. Let us glance at the arguments of Mr. Whitcher and Professor Hind against what the former is pleased to style the "American theory."

In the report of the Minister of Marine and Fisheries for the year ending the 30th of June, 1871, Mr. W. F. Whitcher, Commissioner of Fisheries, published a paper entitled "American theory regarding the migration of the mackered refuted".*

Mr. Whitcher opens his letter by claiming that the theory of north and south migration was invented solely in support of a claim advanced by citizens of the United States to participate in the Canadian inshore fisheries. "This ingenious but traditional theory of annual migration having gained local credence among some of the Nova Scotian fishermen engaged in United States fishing-vessels, has been sagaciously indorsed and circulated by American authors." He also refers to evidence "supposed to have been procured among the fishing population of the New England States."

I need only say that these claims are unjust, and that the theory of the annual north and south migration of the mackerel is time-honored, and was held conscientiously by ichthyologists of the United States and the provinces long before the question of fishery treaties assumed its present aspect. It is manifestly unfair to state that, while the theories which prevailed respecting the habits of herring and mackerel were formerly similar, that "in the former case it is probable that traditionary and imperfect information formed the basis of error, while in the latter instance it is most probably founded on misinformation dictated by sectional interests." Mr. Whitcher's own paper upon migration is the only one of American origin in which I have seen scientific method sacrificed to partisan spirit.

Having read Mr. Whitcher's introduction, one might readily predict what sort of an argument he will wrench out of the statements of "such disinterested authorities as may be readily quoted." First he gives extracts from Mitchell and the Edinburgh Encyclopædia regarding the habits of the herring. Granting all that is claimed about the herring, without reference to the liability of these authorities, what do we find? Merely a begging of the question. The habits of the herring and the mackerel are not known to be the same. In many particulars they are

* Pages 186-189.

diametrically different, for the former loves cold water, the latter warm water.

Various provincial writers are now quoted; Mr. Perley, who says that "naturalists now tell us" and "it is now considered settled" that the mackerel is not migratory, but draws off into deep water at the approach of winter, and Mr. Knight and Mr. Fortin, though the reason for these quotations is not apparent, since no reference to the winter habits of the fish can be found therein. He does not refer to the writings of Mr. Ambrose and Mr. Johnson, Canadian writers, who advocate the migratory theory.

Yarrell and Couch are next quoted, though neither of them has ventured to give a decided opinion.

Finally, we have a paragraph compiled from five French encyclopedias, good and bad, no means being afforded of distinguishing the opinions of Cuvier from those of Chenu's literary staff.

Mr. Whitcher's conclusion is this: that "it is clearly neither necessary nor accurate that mackerel should perform the migrations ascribed to them by American writers."

The migrations of the mackerel are neither proved nor disproved by special pleadings of this description. The spirit of Professor Hind's writings is very different. He writes from the stand-point of an investigator, and his book is an important contribution to our knowledge of the habits of fishes in relation to temperature and currents. I feel obliged, however, to call attention to a very serious flaw in his chief argument against the annual migration of the mackerel.

In the chapter on the "Relation of the Supposed Migratory Movements of Mackerel to Isothermal Lines,"* it is claimed that a migration to the north in the spring "presupposes the movements of bodies of the same great schools of mackerel which are alleged to pass Massachusetts Bay from the waters of the coasts of Virginia and New Jersey, not only through from ten to twelve degrees of latitude, but it assumes that they are able to cross in the early summer, and frequently before spawning, numerous isothermal lines in descending order."

He then refers to the article upon the Gulf Stream in Petermann's "Mittheilungen" for 1870, in which the marine isothermals for the different months are shown by means of a chart. A table is given showing the isothermals for July. That of 68° would touch the coast at Delaware Bay, that of 63°.5 at Long Island, that of 59° at Boston, that of 54°.5 at Cape Sable, Nova Scotia, that of 50° at Cape Race, and that of 45°.5 at the Straits of Belle Isle.

From this he concludes that a "a school of fish, moving rapidly from Delaware Bay to the Straits of Belle Isle, would pass in July from a mean temperature of 68° to a mean temperature of 45°, a difference of more than 22° Fahrenheit.

This theory would be very satisfactory if it could be admitted that the

*Hind, *op. cit.*, part ii, pp. 15–17.

isothermals for July indicate the actual temperature of the sea from day to day. In reality the marine isothermals are constantly varying, and, in this respect are different from those printed upon a chart. A glance at the tables in Appendix F, and the conclusions deduced from them in regard to the menhaden (paragraph 85), will show that schools of fish do not find it necessary to force their way through walls of sea temperature, but that their movements from south to north are exactly correlated with the seasonal rise of temperature. As soon as the water at a given point reaches the necessary temperature, which for the mackerel on our own coast appears to be as much as 45°, the fish make their appearance, and with the advance of the season they appear farther and farther to the north. Mackerel do not appear on the coast of Maine until the water is as warm as it was off Cape Hatteras at the time of their first arrival. This is the case whether we suppose their general movement to be parallel with or vertical to the coast line.

I have entered the discussion of this question not with any idea of attempting to prove that mackerel migrate south from the Gulf of St. Lawrence, but to show that a comparatively rapid northward movement in May and June does not necessitate a "sudden plunging from high to low zones of temperature."

Arguments against extended migrations of menhaden.

89. There is no satisfactory evidence that the menhaden pursue extended migrations north and south. The same evidence which tends to show that the shad, salmon, and alewife do not follow this course will will apply, with modifications, to the menhaden.

The menhaden schools at different points along the coast appear to have individual peculiarities, corresponding to those of the shad in the different rivers. A Maine menhaden may easily be distinguished from a Long Island menhaden, a Chesapeake or a Florida one, by certain indescribable characters, easy to perceive but difficult to define. The presence of the crustacean parasite in the mouths of southern menhaden, and its constant absence from those of the north is a very strong argument in favor of local limitation in the range of menhaden schools.

That the same schools of menhaden return year after year to the same feeding grounds is rendered very probable by the statements of Mr. Miles in paragraph 72.

The schools in the southern waters do not receive any apparent increment at the time of desertion of the north coast, nor are the southern waters deserted at the time of abundance in the north. There is, however, a limited north and south migration. The Maine schools on their departure in the fall appear to follow the southward trend of the coast until they strike the hook of Cape Cod, where they are detained for some days; they then round the cape and are again detained by the hook of Montauk Point. They first strike the shore at Point Judith and are

turned over into Peconic Bay by the line of islands stretching across the eastern end of Long Island Sound.

In this same way the Chesapeake schools are said to be detained for some days by the projection of Cape Henry.

The hypothesis of oceanic sojourn of the menhaden.

90. The questions of hibernation and extended migration having been considered, it only remains to discuss the third alternative, that of the possibility of sojourn in the warm strata of the open ocean.

In plate XII is given diagram sections of the North Atlantic Ocean between New York and Bermuda, showing the soundings and isothermal lines obtained in Her Majesty's ship "Challenger", April 24 to May 8, 1873. The vertical scale is necessarily enormously exaggerated, but the diagram shows the presence of strata under the Gulf Stream, and between it and the American coast, the temperature of which exactly meets the requirements of the menhaden. At a depth of 50 to 100 fathoms there is a shoreward extension of the warm stratum of 50° to 55° which extends inward one hundred and twenty miles. There are no means of determining the corresponding isothermal lines on the coast of North Carolina, but an extension of much less degree would approach very near the shore in that region. The diagram represents the condition of the sea temperature near New York at the very period when the menhaden are approaching the coast in April, and a similar relation not improbably exists in November, at the time of their departure. The schools of fish swimming out to sea when the shore waters become too cold for them, and driven below the surface by the winds of November, would naturally strike these temperate strata, and being kept from descending deeper by the uniform coldness of the waters below, as well as by the increasing pressure, and their efforts to approach the shores being also opposed by a temperature barrier, they would remain in the temperate strata until they were enabled by the warmth of spring to regain their feeding grounds near the shores.

No authorities can be quoted in support of this hypothesis, but, in the case of the menhaden at least, it appears to explain more of the difficult questions in relation to periodical movements than that of hibernation or that of extended migration.

(1.) It presupposes less sudden changes of temperature than that of hibernation. It has been shown that hibernation of fishes is never voluntary, but is a state of torpidity induced like that of æstivation by a change of temperature and surroundings which they have no power to avoid. Before entering upon hibernation or æstivation fishes retreat to the deepest water, and only become completely torpid when they are followed thither by the changed conditions of existence. In the fresh waters of temperate regions fishes do not become entirely torpid in cold weather, but are sufficiently active to be taken with hooks from under the ice. This is also the case in very deep waters in subpolar regions. The

kalleraglitz or American turbot (*Reinhardtius hippoglossoides*) is taken with hooks, in the dead of winter, under the floe ice of North Greenland at a depth of 300 fathoms; in South Greenland, on the oceanic banks, at 60 and 80 fathoms; and at Fortune Bay, Newfoundland, it is captured in the shore herring-seines at the same season.

So long as the menhaden can avoid the extremes of temperature which they so carefully avoid in the summer by seeking congenial warmth in the ocean strata under the Gulf Stream, need we suppose that they will plunge into the colder strata below?

(2.) It involves less radical changes than hibernation in the habits of the fishes. Some fishes, like the mud-minnow (*Umbra limi*) of the Eastern United States, are peculiarly adapted for life in the mud; others, such as the "compound breathers" (*Labyrinthici*) of India, are said to respire with ease with their heads covered by liquid mud. Such fishes, however, are totally different in organization from the free-swimming species of the open seas. All free swimmers are especially heedful to avoid contact with the bottom. This is especially so in the case of the herring family, of which the menhaden is a member. They are provided usually with deciduous scales, and never suffer themselves to come in contact with the bottom. If one of the herring or mackerel tribe is placed in an aquarium, it will be noticed that it keeps itself always free from the bottom. Other fishes in the same tank, such as the sea-bass, tautog, or king-fish, will be seen to rest on the bottom, and even to take refuge under the stones.

It is improbable that mackerel ever voluntarily sink into the mud of the ocean bottom; still more so in the case of the menhaden.

(3.) It accounts better than the other theories for the early appearance of the fish in the spring.

Admitting the possibility of a winter's sojourn in the mud, we are met by a difficulty when we try to account for the prompt appearance of the fishes in the spring. The deeper strata of the ocean are now known to preserve throughout the year the uniform temperature of 22° to 40°. The fish, once mummified in the depths of the ocean, would remain so forever, unless they possess powers unknown to exist in other animals.

On the other hand, if we suppose the fish to be swimming in the strata of mid-ocean, we know that they are in just the position to be susceptible to all the daily variations of temperature. Following, with the advance of the season, the inward curving of the Gulf Stream, the warm strata below it gradually approach the shore. The schools of fish are thus enabled gradually to draw nearer to the coast line, and when the strata of 50° to 55° in temperature touch the coast the menhaden are at hand.

(4.) It explains, as well as the hibernation theory and better than the migration theory, the peculiarity of the schools at different localities along the coast. This was discussed in paragraph 88.

(5.) It explains better than the other theories the appearance of the fish at the time of their arrival in the spring.

The menhaden appear to be bottom feeders. If they migrated coastwise to the south, they would there find feeding-grounds; if they sank to the bottom, they would there find food if they had sufficient vitality to resurrect themselves in the spring; if they passed the winter in the mid-ocean strata, they could obtain no food and would naturally become emaciated, the accumulated fat of the preceding summer being absorbed.

Rimbaud's classification criticised and a new one proposed.

91. Rimbaud's classification, which is a modification of one recognized in the markets of South France, is very suggestive, but it does not appear to me to be entirely applicable to the fishes of our coast, at least not in the way in which it has usually been adopted.

Rimbaud makes four divisions, viz:

I. Wandering fishes (*Poisson nomade*).

II. White fishes (*Poisson blanc*).

III. Bottom fishes (*Poisson de roche* or *Poisson de fond*).

IV. Alien or outside fishes (*Poisson forain*).

The distinction between Classes I and IV does not appear to be very clearly marked. In the Western Atlantic, some of the fishes making up Class IV belong to each of the other classes.

A more natural classification would be in three divisions, which might readily be correlated with the three kinds of migration mentioned in the preceding paragraph.

The first group would include the wandering fishes, the *Poisson nomade* of Rimbaud, whose migrations are entirely oceanic and confined to the surface zones. The second group would include the bottom fishes of restricted range, the *Poisson de fond* of Rimbaud, which move to and from the shore or the shallows, and which do not range. The third group would include the middle classes, those which take advantage of both methods of migration, and corresponds approximately to Rimbaud's second division. "White fishes" seems hardly an appropriate name: "coast fishes" would perhaps be more expressive.

Colonel Lyman, in his report "On the Limits of Artificial Culture, and the Possible Exhaustion of Sea-fisheries"* (p. 67), speaks of the first class as "the wandering or schooling fishes of the high seas." The term "schooling" is liable to mislead, for the "white fishes" also school. Among the wandering fishes he mentions only "the herring (*Clupea elongata*), mackerel (*Scomber vernalis*), menhaden (*Alosa menhaden*), cod (*Gadus morrhua*)," &c. The cod and herring most certainly are "white fishes," and the menhaden and mackerel are certainly not to be ranked with "those which appear on the coast only when 'migrating,' and then in vast but uncertain troops" (p. 63).

* Report of the Commissioners of Fisheries (of Massachusetts) for the year ending January 1, 1870, pp. 58–67.

A provisional classification, by habits, of the fishes of our eastern coast might stand somewhat as follows:

I. *Wandering or surface fishes.*—These remain in our waters only for a short time, their movements being capricious or accidentally directed by the ocean currents, or else in search of food. They do not spawn on our coast, and their young are never seen in our waters.

The best-known examples are the sword-fish (*Xiphias gladius*), the spear-fish (*Tetrapturus albidus*), the bonito (*Pelamys sarda*), the tunny (*Orcynus thynnus*), the dwarf tunny (*Orcynus alliteratus*), the ceroes and Spanish mackerel (*Cybium maculatum*, *C. caballa*, and *C. regale*), the rudder-fishes (*Seriola zonata*, *Naucrates ductor*, and *Palinurichthys perciformis*), the dolphins (*Coryphæna*, two or three species), the remoras (*Echeneididæ*), the barracuda (*Sphyræna borealis*), the lady-fish (*Albula vulpes*), the tarpum (*Megalops thrissoides*), the oceanic sharks, such as *Galeocerdo tigrinus*, and the numerous waifs from the West Indian fauna.

Of these only the sword-fish, bonito, and the ceroes and Spanish mackerel are of economic importance at present.

II. *Local or bottom fishes.*—These remain in our waters throughout the year, their movements being chiefly to and from the shores, though many of the species move for long distances up and down the coast. They prefer a somewhat uniform temperature, which they secure by going into the shallows in summer and deeps in winter in the northern districts of their distribution, while in their southern districts of distribution these movements are reversed. They spawn on our coast, usually in shallow water and during their shoreward sojourn.

The principal representatives of this group are the goose-fish (*Lophius piscatorius*), the flounders and flat fishes, the halibut (*Hippoglossus vulgaris*), of whose spawning habits little, however, is known, the lump-fish (*Cyclopterus lumpus*), and the two species of *Liparis*, the cod (*Gadus morrhua*), haddock (*Melanogrammus æglefinus*), pollock (*Pollachius carbonarius*), and the hakes (*Phycis chuss* and *P. Americanus*), the gurnards and sculpins (*Prionotus*, sp. and *Cottus*, sp.), the rose-fishes (*Sebastes*, sp.), the tautog (*Tautoga onitis*), and the chogset (*Ctenolabrus chogset*), the skates, the rays, and the ground-sharks.

III. *The coast or ranging fishes.*—These are in our coast waters for a portion of the year, and when absent from them are supposed to retreat to the depths of the ocean. When near the shores their movements are a combination of those of the two previous classes, and they wander widely up and down the coast. They spawn upon our continental slope, some entering the rivers, some upon the inshore shallows, and some upon the off shore shoals, their young coming to the shores with the parents. They all are summer visitors in the northern districts of their distribution, though some, like the herring, only appear in New England in the winter.

The best-known examples of this group are, among the river-spawning or anadromous species, the salmon (*Salmo salar*), the shad (*Alosa sap-*

idissima), the alewife (*Pomolobus pseudoharengus*), the mattowacca (*Pomolobus mediocris*), and perhaps the striped bass (*Roccus lineatus*) and the smelt (*Osmerus mordax*); among the shore-spawning species, in the north, the capelin (*Mallotus villosus*), the launce (*Ammodytes lanceolatus*), and the herring (*Clupea harengus*); in the south, the scuppaug (*Stenotomus argyrops*), sheepshead (*Archosargus probatocephalus*), the sea-bass (*Centropristis atrarius*), the atherines (*Chirostoma notatum*), the mullet (*Mugil*, sp.), and the mackerel (*Scomber scombrus*); and among the off-shore spawners the pompano (*Trachynotus carolinus*), the squeteague (*Cynoscion carolinensis* and *C. regalis*), the menhaden (*Brevoortia tyrannus*), and probably the bluefish (*Pomatomus saltatrix*).

14.—The movements of the schools.

Habits of the schooling fish.

92. Making their appearance in our waters in the early spring, they rapidly increase in abundance until the sea appears to be alive with them. They delight to play in inlets and bays, such as Chesapeake Bay, Delaware Bay, Great Egg Harbor, Long Island, Block Island and the Vineyard sounds, Narragansett Bay, Buzzard's Bay, and the numerous narrow fiords on the coast of Maine. They seem particularly fond of shallow waters protected from the wind, in which, if not molested, they will remain throughout the season, drifting, with the tide, in and out of the shallow indentations of the shore and into the mouths of creeks and rivers. Brackish water attracts them, and they abound at the mouths of streams, especially on the Southern coast. They ascend the Saint John's River more than thirty miles, the Saint Mary's, the Neuse, the York, and Rappahannock. The Potomac they ascend nearly to Washington, a distance of sixty miles, and the Patuxent to Marlborough. In these rivers they come soon after the shad, and are so troublesome to the fishermen that their presence is easily determined.

I am not aware that this difficulty occurs in northern rivers. Professor Baird found them in the Hudson and its tributaries in the summer of 1854.*

They enter the Housatonic late in the summer. I am not aware that they ascend the Connecticut to any considerable distance from its mouth.†

They are found in the Mystic, Thames, and Providence Rivers, in the creeks on Cape Cod, in the mouth of the Merrimac River, and in some of the large rivers of Maine, such as the Kennebec and Penobscot.

Boardman and Atkins state that fish caught in the brackish water of the rivers are generally inferior as to fatness, "a fact indicating that they find there a poor feeding ground, and also that their stay there is long enough to affect their condition."

---

*Fishes of the New Jersey Coast, 1855, p. 34.

†This is perhaps due to the swift current of the river. Sea-going vessels fill their water-barrels at Essex, six miles from the bar.

Movements to and from the surface.

93. The arrival of the menhaden is announced by their appearance at the top of the water. They swim in immense schools, their heads close to the surface, packed side by side, and often tier above tier, almost as closely as sardines in a box. A gentle ripple, caused by the motion of the vertical fins, indicates the position of the school, and this may be seen at the distance of nearly a mile by the lookout at the masthead of a fishing-vessel, and is of great assistance to the seine-men in setting their nets. At the slightest alarm the school sinks toward the bottom, and in this way often escapes its pursuers. When sailing over a school of menhaden, swimming a short distance below the surface, one may see their glittering backs beneath, and the boat seems to be gliding over a floor inlaid with blocks of solid silver. At night they are phosphorescent and their backs glow like fire. The motions of the schools seem capricious, and without a definite purpose; at times they swim around and around in circles, at other times they sink or rise. Why they swim at the surface so conspicuous a prey to men, birds, and other fishes, is not known; it does not appear to be for the purpose of feeding; perhaps the fisherman is right when he declares that they are "playing." When they are pursued by other fish they fly in confusion like a flock of frightened sheep, and are often driven in great masses upon the shores.

The swimming habits of menhaden and mackerel.

94. An old mackerel-fisherman thus describes the difference in the habits of the schools of mackerel and menhaden:

"The pogies school differently from mackerel. The pogy slaps with his tail, and in moderate weather you can hear the sound of a school of them as first one, then another, strikes the water. The mackerel go along 'gilling'—that is, putting the sides of their heads out of the water as they swim. The pogies make a flapping sound, the mackerel a rushing sound. You can sometimes, in calm and foggy weather, hear schools of mackerel miles away."

Birds attracted by the schools.

95. They do not attract terns, as do the schools of predaceous fish, for they are too large to be an easy prey for those birds, and they are not in pursuit of crustaceans or smaller fish, which might also serve as food for the small birds. The bluefish and bonitos are attended by eager flocks of gulls and terns, which find a bountiful supply in the remnants of their voracious feasting, floating on the surface in their wake. The fish-hawk (*Pandion carolinensis*) often hovers over the schooling menhaden, and some of the larger gulls occasionally follow them in quest of a meal. About Cape Cod one of the gulls, perhaps *Larus argentatus*, is known as the "pogy-gull."

The influence of wind and weather.

96. On warm, calm, sunny days they may always be seen at the surface, but cold or rainy weather, and prevailing northerly or easterly winds, quickly cause them to disappear below the surface. In rough weather they are not so often seen, though schools of them frequently appear at the surface when the sea is too rough for the fishermen to set their nets.

Mr. Atkins and Mr. Dudley agree that the best days for menhaden-fishing is when the wind is northwesterly in the morning, dying out in the middle of the day, and then springing up again in the afternoon from the southwest, with a clear sky. At the change of the wind on such a day the menhaden come to the surface in large numbers.

A comparison of the influences of the weather upon the movements of the menhaden and its allied species, the herring, gives some curious results. The herring is a cold-water species. With the advance of summer it seeks the north, returning to our waters with the approach of cold weather. The menhaden prefers a temperature of 60° or more, the herring of 55° and less. When the menhaden desert the Gulf of Maine they are replaced by the herring. Cold weather drives the menhaden to the warmer strata below, while it brings the herring to the surface.

The observations of Herr von Freedon, of Hamburg, director of the German See Warte,* are important in this connection. Herr von Freedon made a thorough analysis of the log-books of the luggers engaged in the German herring fishery, and made an elaborate report to the Fishery Commission at Embden upon the influences which affect this fishery, especially the influence of winds and the temperatures of the sea. He has come to the conclusion that northwest winds are the best for large catches, and northerly winds better than southerly, westerly better than easterly; also that moderately strong winds, sufficient to ruffle the surface of the sea, are better than calm weather, and light winds almost as unfavorable as stiff breezes; a ruffling of the sea being, in his opinion, of considerable importance to success in fishing. For the temperatures of the sea, he regards a temperature from 53° to 57° as most favorable, the chances of success diminishing with higher or lower temperatures.

The conditions most favorable, then, for the appearance of herring at the surface are least so for menhaden, it being borne in mind that northwesterly and westerly winds on the east side of the Atlantic correspond to northeasterly and easterly winds upon the west side.

The movements of the herring as influenced by weather.

97. In the "Scotsman" of August 25, 1876 (quoted in "Nature"), is an interesting observation regarding the movements of the herring on the Scottish coast. The surface temperatures of the sea, as determined by the sea-thermometer furnished to the fishermen by the Scottish Meteorologi-

* See Report of the Commissioner of the Fishery Board of Scotland, 1875.

cal Society, is regarded to have been from 58° to 59° during the week ending August 19, but on the 21st, when the nets were shot, the temperature had fallen to 55°, and this was the first night the herring were caught. They were found low in the nets during the prevalence of warm weather between Northumberland and Peterhead.

"The Meteorological Society of Scotland have for two or three years had this capriciousness in the movements of the herring under special investigation, and in the past year the deep-sea thermometers provided to the society by the Marquis of Tweeddale, its president, for testing the temperature of the sea, were again sent out by the Fishery Board to their officers, and the temperature obtained at different periods of the herring fishery. Daily registers of the weather were kept and other particulars furnished to the society, both by the district fishery officers and by Samuel McDonald, esq., commander of the "Vigilant," fishery-cruiser. From the registers and the information thus supplied, the following conclusions have in the mean time been drawn by the committee of the society:

"From the observations of the catch of herrings and the temperature of the sea off the east coast of Scotland, during the two seasons of 1874 and 1875, it is seen (1) that the temperature of the sea from the middle of August to the close of the fishing season was continuously and considerably higher in 1875 than 1874; and (2) that the catch of her rings was continuously and considerably lower during 1875 than during the same period of 1874.

"Another result is this: If there be a district where, from any cause, the temperature of the sea is lower than in surrounding districts, in that district the catch of herrings is heavier; and conversely, if there be a district where, from any cause, the temperature of the sea is higher than in surrounding districts, in that district the catch of herrings is less. Among the causes which bring about a local increase or decrease of sea-temperature, the chief are clouded or clear skies in respective districts, according as these occur during the day or during the night. These local variations in the temperature of the sea in their bearings on the catch of herrings have been shown by the observations both of 1874 and 1875.

"Another important point is the relations of surface temperature to bottom temperature, and the relations of the deepest parts of the sea to the positions of the fishing grounds. It is found, for instance, that when the surface temperature is high—higher than lower down—the fish, if any be caught, strike the nets far down, in such a way as to lead to the supposition that a good deal of failure may often arise from the nets not going deep enough. The fish prefer, apparently, so far as the inquiry has gone, the lower to the higher temperature. The herring committee are most desirous of carrying out this line of inquiry into greater detail, if some of the fishermen could be induced to take the trouble of observing the temperature of the sea at the surface and also at the depth at which the fish strike the nets.

"The influence of thunder-storms was equally seen as in former years. If there is a thunder-storm of some magnitude extending over a large portion of Scotland, good takes may be made on that day; but on the following day few, if any, fish are caught over that part of the coast *unless at the extreme verge of a deep part of the sea*, as if the fish were retreating thither.

"Owing to the shortness of the time over which the inquiry has extended, the committee wish these results to be considered only as provisional. The results are, however, of the greatest value, not merely as indicating the lines of inquiry to be followed in further carrying on this large investigation, but also as indicating, in some cases not obscurely, the nature of the results which will ultimately be established—results which, since they lead directly to a knowledge of the localization of the herring, will serve as a guide to the fishermen where to set their nets with the highest probability of success."

The influence of the tides on the menhaden.

98. There has been no decided relation observed between the movements of the schools and of the tide.

Following the coast in its northward trend they crowd into the bays and sounds, and breaking up into smaller schools the detachments find their way into the shallows. In outside waters they do not appear to be affected by tides, and when they are migrating they seem independent of its influence. Mr. Dudley states that they often rise to the surface when the tide changes near the middle of the day. This is doubtless in waters near the shore, where the change of tide would be accompanied by some slight change of temperature. Mr. Simpson feels certain that more enter the inlets of North Carolina on the ebb than on the flood. It seems to be true, however, that throughout their halt during the summer, many schools drift lazily with the tide into the bays and creeks, coming in with the flood-tide, going out with the ebb-tide. In Southern waters they appear to hug the shore as closely as they can, and at high water thus gain access to waters too shallow for them at any other time.

15.—ALLEGED CHANGES IN HAUNTS AND HABITS.

The alleged changes of habit caused by the fisheries.

99. Many of the remarks in the preceding chapter are applicable to the menhaden only when they are left to enjoy their favorite haunts undisturbed. On the coast of Maine their habits are said, temporarily at least, to be greatly modified through the influence of man. They no longer hug the shores, but are found many miles out at sea, where they are followed by the fishing-vessels. The introduction of steamers into the fisheries is an evidence of this change of habit, and indeed the almost unanimous testimony of the Maine fishermen, from whom letters

have been received, is that the use of nets and seines tends to scare the fish farther out to sea. The purse-nets are set generally at a distance of from five to twenty-five miles from land.

Off Penobscot Bay menhaden are frequently caught by Brooklin fishermen outside of Isle au Haut and Great Duck Island.

According to Mr. W. H. Sargent the fish are much less numerous in the creeks, coves, inlets, and rivers, though outside no decrease is perceptible.

Capt. William S. Sartell, keeper of Pemaquid Point Light, writes: "The menhaden come regularly every summer into the bays, but the seining draws them off out of sight of land so that the fishermen here can't get bait to put on their hooks. They get some fish in their nets on Sundays when the seines are laid by."

Mr. Babson writes: "Since they have been taken in large quantities for their oil, they have gradually avoided the bays, creeks, harbors, and rivers to which they once resorted in immense numbers, and are now principally taken from one to ten miles from the shore. (Some of the fishermen maintain that since the advent of the bluefish, some twenty years ago, the pogies have sought deeper water for their own safety, while others maintain that the bluefish drive the pogies into shoal water; both statements are doubtless at times true.)"

Mr. Kenniston states that the fish are now farther off shore than in former years, and in this he is confirmed by Mr. Phillips, who states that they are taken better off shore where the seines cannot touch bottom. On the other hand, Mr. Washburne and Mr. Brightman are of the opinion that the use of the seine does not influence the movements of the fish.

Mr. Church, who has had much experience in the fisheries of Rhode Island, is very positive in his opinion. He writes: "The nets and seines do not scare the fish from the shore, for Narragansett Bay has been the theater of their greatest capture for forty years or more, and they have been more plenty than ever before known for the last ten years. I have seen a school of fish set at ten times in succession in deep water, and they would dive under the seine each time, but when they came to the surface they would not be ten feet from the seine, and they would lie still until we got ready to set, and when the seine was around them they would dive again. Fish will drive menhaden but man never does, except by use of powder; the menhaden are sensitive to a jar, such as is caused by striking the deck of a vessel with an ax. Even so slight a jar as the dropping of an oar or the careless slat of a rung on the gunwale has sent a school of fish off at top speed." Mr. Dudley confirms this. Steamers must carry low-pressure engines and run as noiselessly as possible.

Fishermen on Long Island Sound and about its eastern entrance seem to be divided in opinion. Messrs. Sisson, Havens, B. Lillingston, Washington, Crandall, and Dodge incline to think that fishing with nets

drives the fish away, while Messrs. Whaley, Potter, Wilcox, Beebe, Ingham, Miles, F. Lillingston, and Hawkins Brothers share the opposite belief. It should be noted in this connection that in Long Island Sound and vicinity purse seines worked off shore have almost superseded the haul-seines used twenty or thirty years ago, which were worked from row-boats and drawn up on the beaches. Does not this point to a change in the habits of the fish? In this district, where the fisheries are mostly prosecuted in waters more or less land-locked, the fish are not so apt to be driven out to sea as in Maine, where the fishing is prosecuted on an open coast. The timid fish may easily be crowded out into deep water by the vessels, which, working from the shore, usually approach them from that direction. If the fisheries of Maine were to be suspended for a short time the fish would doubtless return in full force to their former haunts. It appears from the statement of Mr. Sartell, already quoted, that they appear inshore in considerable numbers if the large seines are laid up for a single day. Mr. Simpson thinks that a school which is frightened away by nets returns to the same place in the course of two or three hours. South of Long Island, menhaden fisheries have not been carried on to such an extent as to exert any modifying influence upon the habits of the fish.

The opinion of Mr. Atkins.

100. There is room for difference of opinion on this subject. Boardman and Atkins do not accept this view, and after the thorough study they have made, their views are entitled to much respect. They remark:

"In general, it is safe to say that the surface movements of the menhaden are characterized by nothing so much as by capriciousness. They appear suddenly in the most unexpected spots, and, after a stay whose length nobody can foretell, all at once they disappear. One day they may be found at the mouth of the Kennebec, the next at Pemaquid, and the third all along the shore. Occasionally they reappear daily in the same spot for weeks at a time. Such was the case in the latter part of the season of 1874, over the sandy bottom off the Phipsburg beaches. Then it will sometimes happen that a whole season will pass without their appearance in bays where they have previously swarmed. Again, in some seasons they crowd the harbors and coves; in others they seem to avoid them altogether. For some years past they have so generally absented themselves from these places as to excite a good deal of speculation as to the cause."*

And again:

"Of the desertion of the harbors and coves there seems to be abundant testimony. An observer in Boothbay says: 'Menhaden can be driven out of small bays so that they will not come in.' 'Certain it is that they do not come into the bays as they used to.' In Bluehill we are

**Op. cit.*, p. 11.

told the same story. In Jonesport it is said, 'Pogies used to run into all the coves and creeks. Of late years they do not appear to frequent the shores as formerly.' Testimony of this sort might be multiplied; but it is unnecessary. The fact is notorious. During the past season (1874) they returned to some of their old haunts in great numbers, but have by no means resumed their former habit in this respect. Of this singular change of habit there are various explanations offered. According to some persons it is caused by the practice of seining; others lay it to the oil and decaying matter from the oil-factories. Neither of these causes appears sufficient to produce such a result. The desertion of the coves is observed in localities far removed from those where the alleged causes have operated. Perhaps, after all, the thing to be accounted for is why the menhaden ever crowded into small bays as they used to. Were they there in search of food, were they simply obeying blind instinct, or were they driven in by hordes of hungry foes outside? The latter supposition seems quite as probable as the others. We know that small fishes sometimes rush ashore to escape pursuit; we know that this happens with herring when flying from the pollock, and with menhaden when flying from the bluefish and horse-mackerel. The presence, outside, of a large number of predaceous foes, of whatever species, would be ample to drive the menhaden in. This might happen year after year; while with the cessation of the cause the result would cease too, and the menhaden would no longer crowd into the coves as before. If this view be correct, then the recent absence of the menhaden from the shores indicates an improvement in its chances of life, by the removal of its destroyers. Lack of information forbids an attempt to point out the species that have been most active in producing these movements of the menhaden; and indeed the theory itself is not proposed as one that has much of positive evidence in its favor, but just to show the possibility of accounting for the absence of the fish from shore on the hypothesis of the operation of causes purely natural, and not inimical, but positively favorable."

The opinion of Mr. Maddocks.

101. Still another view is advanced by Mr. Maddocks: "The menhaden, it is believed, does not of its own preference visit the coves and inner harbors, for its food seems to be less abundant in such localities, but to be driven into them by predaceous enemies. Upon the withdrawal of these, either in part or in full, the menhaden may reoccupy their former haunts at a remove from the shore, and thus disappear from inner waters."

I hardly think that the facts support this opinion. The habits of the fish when undisturbed, as they may be studied on the thousand miles or more of coast south of Cape Cod, are a safer guide than their habits on the much-seined coast of Maine.

102. Boardman and Atkins record some very interesting facts regarding

the change in the northern limits of the range of the menhaden within the past thirty years.

At Jonesport, Me., menhaden used to be very plenty. They were commonly caught in gill-nets two and one-half fathoms deep, but it was practicable, almost any time, to get enough to go fishing with by spearing. They became scarce seven, eight, or ten years ago, and now very few are caught, although some come as far as this every year.*

At Lubec, thirty years ago or more, menhaden were so plenty during their short season (July and August) as to be a nuisance. They have not been plenty since 1840 or 1845, and now none are found east of Jonesport. They left suddenly, and since the date mentioned have been rarely seen. Mr. E. A. Davis, of Lubec, a man of long experience in the herring fishery, has not seen a single specimen for ten years. Mr. E. P. Gilles, also of large experience, in 1860, or thereabouts, got three hogsheads of them one afternoon tide, and since then has seen none.

At Pembroke, says Mr. Moses L. Wilder, "twenty years ago, and always before that, the menhaden used to come here every year in great numbers, filling every cove and creek; but for the past twenty years none whatever have been seen. Little use was ever made of them except for bait, and of that but little was needed here."†

There is also evidence to show that the waters of Nova Scotia and New Brunswick have of late years been entirely deserted by them.‡

E.—ABUNDANCE.

16.—ABUNDANCE IN THE PAST.

The testimony of early writers.

103. Of the abundance of menhaden in times gone by we can know very little, for they have never been considered an important species, and might easily escape the observation of writers. We infer that they were abundant the time of the Dutch colony on New York Island, two hundred years ago, from the name given to it by the New Netherlanders; in fact we have the statement, already quoted, of Dankers and Sluyter, who before 1679 saw in the bay of New York "schools of innumerable fish, and a sort like herring, called there *marsbanckers*." L'Hommedieu speaks of their abundance at the close of the last century.§

Professor Mitchill, writing in 1814, states: "They frequent the New York waters in prodigious numbers. From the high banks of Montock, I have seen acres of them purpling the waters of the Atlantic Ocean. The waters of Long Island Sound and its bay are often alive with schools of them."¶

* Statement of Z. D. Norton.

† Boardman & Atkins, *op. cit.*, p. 21.

‡ See below, paragraph 222.

§ Agricultural Transactions of New York, I, p. 65. See Appendix O.

¶ Transactions of the Literary and Philosophical Society of New York, 1815, I, p. 453.

In his deposition to Professor Baird, August 3, 1871, Capt. Nathanael Smith, an aged Newport fisherman, gave the following testimony: "Menhaden are decreasing too. In 1819 I saw a school of menhaden out at sea, when I was going to Portland, that was two miles wide and forty miles long. I sailed through them. We were out of sight of land. They appeared to be all heading southwest. There were no fish near them. I have seen a school on this coast three miles long. I think they spawn in April and May."*

Dr. DeKay, in his "Natural History of New York," says of this fish that, "although it is seldom eaten, as it is dry, without flavor, and full of bones, yet it is one of the most valuable fish found in our waters. They appear on the shores of Long Island about the beginning of June, in immense schools; and as they frequently swim with a part of the head above or near the surface of the water, they are readily seen and captured. They are commonly sold on the spot at the rate of $2 the wagon-load, containing about 1,000 fish. The largest haul I remember to have heard of was through the surf at Bridgehampton, at the east end of the island. Eighty-four wagon-loads, or, in other words, 84,000, of these fish were taken at a single haul."

Mr. George H. Cook, writing in 1857, thus speaks of the abundance of menhaden on the coast of New Jersey:

"The moss-bonker (the *Alosa menhaden*, or *Clupea menhaden*), or, as it is sometimes called, bony-fish, menhaden, and other names, is an abundant fish in all the waters of this part of the State. It is frequently seen in immense shoals, fairly blackening the water for many miles. It is easily caught, and in large quantities at once. Mr. John Stikes, sen., of Beesley's Point, with his brother, some years since, caught, in a ninety-fathom net, thirty two-horse wagon-loads, at four hauls, taking fourteen of the loads at a single haul. Last summer, in a trip through the sounds from Beesley's Point to Cape Island, we passed through water filled with these fishes. Many of them swam so near the surface that their back fins projected above it; and the appearance of the water was entirely changed by the slight ripple they made In moving. They were most abundant then in the vicinity of Hereford inlet; but they are found near all the shores; and the only limit to the amount which can be taken is in the ability to take care of them when caught. Sixty wagon-loads, of at least 2,500, fish each, were taken at one haul in Raritan Bay this season."

17.—Abundance in the present.

On the coast of Maine.

104. Mr. W. H. Sargent considers the pogy the most numerous fish on the coast of Maine. Their capture affects their abundance in the coves and rivers and along the shore, though not outside. In 1873, Friend & Co.,

* Report of the Commissioner of Fish and Fisheries, 1871–'72, p. 21.

of Brooklin, took 25,000 barrels; Allen & Co., 15,000; others in the vicinity, 85,000. In 1874, about 15,000 were taken, the larger portion by Friend & Co. Between 1863 and 1868, some years 500,000 barrels have been taken. In 1877, Mr. Sargent estimates the total catch in his district at 100,000 pounds, or less than 400 barrels. Mr. J. C. Condon states that the fish are quite abundant about Belfast, Me.; 2,000 barrels were taken in the Belfast customs district in 1873; 3,000 in 1874. Seining does not appear to diminish their number. According to Mr. R. A. Friend, the pogies are much more numerous about Brooklin, Me., than any other fish; their numbers are not apparently diminished. About 14,000 barrels were taken in that vicinity in 1873, and 23,000 in 1874.

Mr. John Grant writes that, though pogies are more numerous about Matinicus Rock than any other fish except the herring, their numbers are decidedly diminished, probably on account of their wholesale capture.

Mrs. B. Humphrey states that at Manhegin Island these fish are more numerous than any other, but that seining has greatly affected their abundance.

Captain Coombs, of Esterbrook, who fishes for the Brightmans at Round Pond, Bristol, Me., recently caught with his seine, at one haul, 1,300 barrels of menhaden, and saved 1,179 barrels, made and valued as follows: Thirty tons scrap, at $10 per ton, $300; 3,650 gallons of oil, at 60 cents per gallon, $2,190; total, $2,490.*

At Sargentsville, Me., according to Mr. W. G. Sargent, 1,500 barrels of pogies were captured, in 1877, by Herrick & Bayard's boats. These were taken to the factories in the adjoining township of Brooklin.

Capt. Frank A. Chadwick, of New Harbor, Me., states that seven purse-seines are used in that vicinity, which catch an average of 15,000 barrels of menhaden annually, and a total amount of 125,000 barrels.

Mr. William P. Sprague, of North Isleborough, Me., writes that pogies are extremely abundant in that vicinity. A fleet of menhaden steamers, some twenty in number, has fished much here.

Mr. Lewis McDonald, of North Haven, Me., estimates the catch of menhaden for 1877 at 400 barrels.

The number of fish taken about Booth Bay and Bristol is given in the report of the Maine Oil and Guano Association, cited elsewhere. Mr. Sartell thinks that the fish are driven away by the seines. Mr. Kenniston and Mr. Brightman think that there is no perceptible diminution, as they continue by far the most numerous species. Mr. Washington Oliver thinks that they have been diminished by the fisheries about Booth Bay.

Mr. Kenniston states that in the town of Booth Bay, in 1873, 152,000 barrels were taken by five factories, as follows: Kenniston, Cobb & Co., 17,000; Gallup & Holmes, 17,000; Gallup & Manchester, 25,000; Suffolk Oil Works, 48,000; Atlantic Oil Works, 45,000. In 1872 the aggregate reached 110,000 barrels; in 1871, with six factories, about 95,000; in

* Boston Semi-Weekly Advertiser, August 27, 1872.

1870, less than 75,000; while in 1866, the first year of the work, only about 35,000 barrels were taken. Judson Tarr & Co. think that they are more plenty than ever before, but not so numerous inshore.

Mr. Edward E. Race, of East Booth Bay, Me., reports, November 5, 1877, the total catch for the season in that vicinity at 156,000 barrels, or 51,948,000 fish.

Mr. W. A. Abbe, manager of the Pemaquid Oil Company, states that the season of 1877 was a poor one, both in the number and quality of the fish taken. The company's fleet of five steamers took during the season over 61,000 barrels (20,000,000 of fish), yielding about 127,000 gallons of oil and 1,800 tons of guano. The fishing began off Gloucester, thence extended to the coast of Maine, and ended off Provincetown. Some of the steamers fished for other parties after the close of the Provincetown season off Newport and Sandy Hook, but the catch was insignificant.

The three steamers owned by Edward T. Deblois took, in 1877, on the coast of Maine, 26,649 barrels (9,000,000 of fish).

Mr. George Devoll, of Fall River, Mass., fishing in 1877 for the Narragansett and Atlantic Oil Works in Maine, caught from his steamer, the Chance Shot, about 12,000 barrels of menhaden.

In 1877, Gallup & Holmes took 52,000 barrels of fish on the coast of Maine and at Provincetown, besides 8,000 barrels caught and sold further west. These fish yielded 120,000 gallons of oil and 1,500 tons of guano.

On the coast of New Hampshire.

105. Mr. Chandler Martin, of Whale's-Back Light, near Portsmouth, N. H., in his communication of February 23, 1874, reported that the fish were diminished January 9, 1875; he writes that they were more abundant in 1874 than for ten years previous, and that they are probably not affected by the fisheries.

Mr. Winslow P. Eayrs, of Nashua, N. H., calls attention to the rapid diminution of the pogies in that vicinity, attributing it to the extensive operations of the oil-factories and to the pollution of the waters by the refuse dye-stuffs and chemicals from the factories.*

On the coast of Massachusetts.

106. Mr. W. W. Marshall estimates the catch of gill-nets at Rockport, 1877, at 1,000 barrels. The fisheries at Newburyport are described below.

According to Mr. Babson the pogies are more numerous about Cape Ann than any other fish except herring and mackerel. He thinks they have decreased somewhat during the past ten years and keep more off the shore. Statistics of capture are given elsewhere.

* Report of the Commissioner of Fish and Fisheries for 1871–'72, p. 136.

About Marblehead, Mass., says Mr. Dodge, they are greatly diminished and are less numerous than most other species.

Mr. Horatio Babson states that the value of the catch of menhaden off Gloucester in 1876 was nearly $800,000. Mr. George W. Plumer estimates $750,000 for the New England coast. George Norwood estimates its value at from $300,000 to $500,000.

Capt. Charles C. Pettingell estimates the number taken in Salem Harbor at 2,000 barrels. This is probably below the actual figure.

Mr. Horace M. Merchant, of Lanesville, Mass., estimates the catch in that vicinity at 750 barrels. They are taken mostly by gill-nets, 300 of which are in use, and are sold for bait.

Mr. J. G. Pond, of Provincetown, estimates 1,000 barrels for that port.

At Plymouth, Mass., according to Mr. Thomas Loring, the menhaden are very few and are diminishing.

About Wellfleet, Mass., states Mr. Dill, the number is greatly diminished on account of the bluefish; they are not so numerous as the mackerel; the capture for the past eight years (in 1873) has been about $500 worth a year. In 1874 about 6,000 barrels were taken in the bay. Fishing does not appear to diminish their numbers.

Capt. Hanson Graham and Capt. Zephaniah P. Lanman estimate the catch of Wellfleet for 1877 at 20 barrels. This is far too small.

Capt. Henry E. Hatch, of North Eastham, Mass., states that many menhaden are taken in the pounds of that neighborhood.

Capt. Solomon Dinnel, of East Orleans, thinks that 100 barrels are taken in the gill-nets belonging in that town.

At Provincetown and Truro, Mass., according to Mr. David F. Loring, the fish are greatly diminished; they are more numerous than any other fish in late April and May. Only 1,000 to 2,000 barrels were taken in 1873.

At Chatham they are more numerous than any other fish, though they do not enter the bay so plentifully as in former years. From 3,000 to 5,000 barrels have been taken annually for the past six years. Captain Hardy does not think that their abundance is affected by the fisheries.

Mr. Kenney states that at Nantucket pogies are the most numerous fish. They vary in abundance from year to year but for the past ten years, as a whole, their numbers remain about the same. Fishing does not affect them. On the other hand Capt. S. H. Winslow, line fisherman, testifies: "The menhaden are very scarce now (July 19, 1871), and I think we shall lose them too very soon, because they are using them up for oil.* In this month and from the 20th of June the ocean used to appear to be literally covered with menhaden. Now there are not a quarter as many as there used to be. People think they are plenty because by using a purse-net one or two hundred fathoms long they can purse several hundred barrels at a haul."

* Report of United States Commissioner of Fish and Fisheries, 1871–'72, p. 46.

N. B. Tower, of Cohasset, states that menhaden are taken in the weirs located in that town. Mr. A. J. Hathaway estimates the annual catch at 10 barrels.

John W. Cook, of South Dartmouth, estimates the catch for 1877 at 30,000 barrels or 9,990,000 fish.

Warren A. Gifford, of Dartmouth, puts the catch of that town at 465 barrels.

Capt. Darius F. Weekes, of South Harwich, reports "thousands of barrels."

Capt. Remark Chase, of West Harwich, who sets a small weir for shad, herring, and pogies, reports about 2,000 barrels of the latter.

At South Westport, according to Capt. John W. Gifford, there are five seines 120 fathoms long and 20 feet deep used in the capture of menhaden. Their average annual catch is about 300 barrels. Mr. Gifford thinks that 1,500 barrels are taken annually in Westport.

Capt. Eldad Gill, of North Eastham, estimates the catch for that place at three or four barrels.

Mr. Alonzo F. Lathrop, of Hyannis, Mass., thinks that the number of pogies is increasing, though it was not so great in 1873 as in 1874 or the preceding years. They are quite as numerous as other fish, and are not perceptibly affected by fishing. Alexander Crowell testified June 29, 1871, that menhaden were more scarce.*

At Edgartown, Mass., and about Martha's Vineyard, they are more numerous than any other species. Five thousand barrels were taken in 1873 by the pounds; 10,000 in 1872. Fishing is not thought to affect their abundance. According to Mr. Marchant and Mr. Luce, they are not more or less abundant than they were ten years ago.

In the weir at Menemsha Bight, owned by Jason Luce & Co., the number of barrels of menhaden taken in 1869 (April 4 to June 7) was 1,590; in 1870 (April 14 to June 8), 1,375; in 1871 (April 14 to June 9), 3,200; in 1872, 3,800.

At a conference on the subject of fisheries at Edgartown, Martha's Vineyard, September 27, 1871, Captain Rease, acting as spokesman for a number of other fishermen, gave the following testimony:

"The law ought to be uniform. One reason why the pounds were not stopped by the legislature of Massachusetts was, that the Provincetown people made a statement that they could not fit out their vessels with bait unless they had pounds to catch it for them.

"Question. Could they?

"Answer. How did they do it before? They had the same facilities then as now. They used to send to Nova Scotia for bait; now they use only menhaden and herring for bait. Menhaden are getting scarce. The harbor used to be full when I was a boy; but it is a rare thing to find any here now, because they are caught up. They don't catch them at Saughkonet Rocks as they used to. If they keep on catching them up

* Report of United States Commissioner of Fish and Fisheries, 1871–'72, p. 49.

as they have done, we shall have to send to California to get a mess of fish." *

At Waquoit weir, near Wood's Hole, Mass., the number of menhaden taken in 1865 was 211,100; in 1866, 318,510; in 1867, 203,740; in 1868, 124,726; in 1869, 145,710; in 1870, 407,930; in 1871, 235,270.†

On the north side of Cape Cod, in Massachusetts, there are 19 weirs; 10 of these were estimated to have yielded in 1876 16,236 menhaden, giving an average of 1,624 to a weir, making an aggregate for the whole of about 32,480. On the south side of Cape Cod, in 1876, were 22 weirs; 10 of these yielded 1,827,729, and the total yield is estimated at 4,000,000. The number of weirs in Martha's Vineyard Sound is 9; 6 of these yielded 1,395,270, and the total yield is estimated at 2,093,000. The number of weirs in Buzzard's Bay is 30; the yield of 11 in 1876 was 54,878,000, and the total yield is estimated at 162,000,000. The total amount taken in the weirs of Massachusetts is estimated at about 170,000,000.

The returns of the catch of these same weirs in 1877, as given in the Report of the Commissioners of Inland Fisheries, is as follows:

Weirs	1,770,136
Gill-nets	81,256
Seines	600,198

While the estimate given above is perhaps too large, the returns cited are probably much too small.

On the coast of Rhode Island.

107. Mr. Edwin A. Perrin, postmaster, Pawtucket, R. I., puts the catch of the five drag-seines there owned, at 2,500 barrels.

Mr. Daniel T. Church writes: "There are no fish in Narragansett Bay so plenty as menhaden if we take several years as the standard, but if we should take years as they come and name each year separately it would be different. For instance, during 1871, 1872, and 1873, scup appeared in Narragansett Bay in immense quantities. There is no doubt in my mind that there has been, during the years named, more of them than menhaden. But, for a number of years preceding, scup were scarce. A few years since squeteague were more plenty than menhaden, for the bay seemed to be full of them from near Providence to Point Judith, and from Seconnet to Somerset. Menhaden, as an average, have been plenty in Narragansett Bay for the last ten years; but not far from ten years back they were scarce, and some of the fishermen left the business on that account. It is my opinion that the blue-fish were so plenty as to destroy the menhaden in large numbers. It was seriously feared that they were to disappear; but since blue-fish, sharks, and horse-mackerel,

* Testimony in regard to the present condition of the fisheries, taken in 1871. <Report of U. S. Commissioner of Fish and Fisheries, 1871, pp. 39, 40.

† Report of Massachusetts Commissioners of Inland Fisheries for 1871, and Report of United States Commissioner of Fish and Fisheries, 1871–'72, p. 176.

have become, for some unknown reason, scarce, menhaden have grown plenty, and 1871, 1872, and 1873 have been great years in the business. Taking for a basis of estimate that there are eight menhaden factories in Narragansett Bay that use about 20,000 barrels each, it would make the number of barrels caught during the year 1873 about 160,000. We do not think fishermen have any perceptible effect on menhaden, for it is a fact well known that a few years back they were so scarce that boats and seines were in the market at less than half their value. The year 1873 has been the year of surprise and wonder of all years, for the sea has been one blanket of menhaden from the Chesapeake to the Bay of Fundy."

Lieutenant-Governor Stevens, of Rhode Island, who owns a pound in Narragansett Bay, found menhaden more plentiful in 1871 than for many years before.*

Mr. Joshua T. Dodge, of New Shoreham, R. I. (Block Island), writes that menhaden are very plenty, though they are scarce in particular seasons; 1873 was a very good year for them. The fish do not seem to be less numerous, but they are wilder than formerly.

Captain Crandall is of the opinion that about Watch Hill, though still more numerous than other fish, they are considerably diminished in number by the use of seines. The catch of 25 drag-seines, owned in that vicinity, was estimated for 1877 at 100 barrels.

On the coast of Connecticut.

108. Captains Wilcox and Potter, of Mystic Bridge, Conn., think that there is no perceptible decrease in the numbers of bony fish on account of the fisheries, and that they are on the increase. They estimate the amount taken in the neighborhood (from Stonington to Poquannock) in 1873 at 6,500; in 1874 at 109,000 barrels.

Captain Washington, of Mystic River, Conn., is unable to see any decrease of late years.

Capt. S. G. Beebe, of Niantic, thinks that the fish are on the increase, and are more abundant than any other species. He estimates the number taken by Luce Brothers in 1873, three seines, 9,000,000; in 1872, four seines, 13,000,000; 1871, four seines, 17,000,000.

At Saybrook, according to Mr. R. E. Ingham, there is no decrease, and the fish are more abundant than any others.

It is the opinion of Mr. H. L. Dudley that there has been no actual decrease. The wears in the vicinity of New Haven have been as successful in 1877 as in any previous year. In 1871, when the Pine Island fishermen captured 10,000,000 they thought the climax had been reached, but in 1876 the quantity was increased to 18,000,000. The catch for seven years is approximately as follows:

1871	10,000,000
1872	13,000,000

* Report of Commissioner of Fish and Fisheries, 1871–'72, p. 19.

1873	11,000,000
1874	10,000,000
1875	*12,000,000
1876	18,000,000
1877	14,000,000

In 1869, Miles Brothers, of Milford, Conn., are said to have taken 8,000,000 or 10,000,000 of fish; a season's catch which has not yet been exceeded, although their facilities for fishing have been greatly increased.

A correspondent of the American Agriculturist wrote to that paper in 1873,† that during the season of 1872 the factories between New London and Stonington caught 40,800,000 fish, which yielded about 142,000 gallons of oil and 4,080 tons of scrap.

The season of 1877 has been an eminently successful one for the fishermen of Long Island Sound. From Pine Island Mr. Dudley counted at one time 30 schools of fish. This year, however, the fishing has been most successful around and outside of Montauk Point.

Gurdon S. Allyn & Co., with three seines worked from sloops took in 1877, 13,000,000 of fish, yielding 42,000 gallons of oil.

Luce Brothers, of East Lyme, Conn., with one steamer and nine sloops, with 48 men, took in 1877, 3,800,000, fish producing 103,200 gallons of oil.

There are eighteen weirs in the harbor of Westbrook, Conn., which take, according to Capt. J. L. Stokes, about 8,000 shad and 500,000 menhaden each, giving an annual yield of 144,000 shad and 9,000,000 menhaden. This is probably rather an overestimate. The Westbrook weirs have leaders of 250 to 500 fathoms, and are managed by four men each. The menhaden taken in them are sold to farmers.

The following are the returns of George Stannard & Co.'s pound at the mouth of the Connecticut:

Year.	Shad.	Small shad.	Whitefish.	Alewives.
				Barrels.
1858	1,200	....	446,090	15
1859	1,032	....	990,600	11½
1860	1,294	....	549,650	25¾
1861	4,381	602	771,930	16½
1862	4,056	667	1,144,410	48
1863	9,400	1,655	678,070	12
1864	8,305	1,248	569,040	11¼
1865	7,069	1,320	642,107	10½
1866	8,891	892	855,575	12¾
1867	9,469	1,214	1,113,158	27
1868	8,781	2,212	219,070	9½

Captain Stokes, with a shore-seine of about 400 fathoms, took during the season of 1877 about 1,000,000 menhaden, which were chiefly sold to farmers at $1.25 the thousand.

Mr. Miles, of Milford, Conn., states that there are no fish in the waters of the western part of Long Island Sound to be compared in numbers

* In 1875 the steamer was first used by the Quinnipiac Fertilizer Company.

† American Agriculturist, 1873, vol. xxxii, p. 139.

with the whitefish, and that so far from being diminished by capture they appear to be on the increase. The men in the employ of the George W. Miles Company, took 12,000,000 fish in 1873, 10,000,000 in 1872, 8,000,000 in 1871, and 8,000,000 in 1870.

Mr. F. Lillingston, of Stratford, states that the propotionate abundance of whitefish to any other species is about 1,000 to 1. About 5,000 barrels are taken each year. Fishing has no effect on their numbers, though previous to 1874 they were growing scarce close to the shore.

On the coast of New York.

109. In the eastern district of Long Island, according to Captain Sisson, the mossbunkers are, and seem likely to be, the most numerous species. He estimates that the number taken by purse-nets in 1873 was 50,000,000, by other nets 10,000,000. Captain Sisson.

Mr. Joseph D. Parsons, of Springs, Suffolk County, New York, estimates the total catch of 1877 at 150,000,000 of fish; 1,150,000 of these he credits to the 50 pounds and traps.

During the three months ending June 30, 1872, there were 20,000,000 of menhaden caught in Gardiner's and Peconic Bays. These fish were rendered into 14,400 gallons of oil and 1,500 tons of guano, and yielded $80,000. The business of the year it is stated will be a failure. In 1871 the receipts of the season amounted to $456,000.*

New York papers of August, 1872, stated that during the two weeks ending on the 17th of the month, the waters of Long Island Sound swarmed with menhaden. One fishing company took 1,300,000, realizing $1 per thousand; another took 3,000,000. One company had rendered 5,000,000 into oil and guano during the season, not running to its full capacity. The price of the fish, formerly 60 cents per hundred, had been reduced to $1 per thousand; yet the fishermen asserted that they could make money at the latter rate if they could sell their whole catch, but only one-third had been taken by the factories.

During 1871 24,520,000 menhaden were taken in the Eastern Long Island Bays. In less than one week, in 1872, six companies took 1,650,000. The "Cove Company" was said to have surrounded with its nets 1,000,000 at a time, but through a fault of the nets only 400,000 were taken. One of the pound nets became so full that the crew could not haul it, and the fish succeeded in breaking it loose from the stakes; it was afterward washed up on the bar. By actual count it contained over 800,000. In two weeks, in 1872, the seines took over 2,000,000.

The two steamers and three sloop-yachts of Hawkins Brothers, Jamesport, N. Y., took in the season of 1877 29,500,000 fish, yielding 82,350 gallons of oil and 3,275 tons of scrap, about one-half of which was dried fresh from the presses.

The two sloop-yachts of William Y. Fithian & Co., Napeague, N. Y.,

*Public Ledger, Philadelphia, July 17, 1872.

seined in 1877 10,500,000 fish, which yielded 24,000 gallons of oil and 1,300 tons of scrap.

The Sterling Company of Greenport, N. Y., took in 1877, with three seine-yachts and six lighters, 14,449,000 fish.

The steamers often make wonderful captures. The "Cambria," Capt. Lorenzo Tallman, is, I am informed, one of the most successful, fishing chiefly outside of Montauk. In 1876 this steamer was brought to the factory, loaded to the water's edge, thirty-six days in succession. In 1876 the "William Spicer" captured 729,300 fish in five days.

Review of the fisheries of New England since 1875, *by Mr. D. T. Church.*

110. Mr. D. T. Church, who is recognized to be one of the leading spirits in the menhaden fisheries, gives the following estimate of the success of the fisheries for three years past:

"1875 was a successful year; so was 1876. The year 1877 from New York to Cape Cod was the best since 1870. North of Cape Cod it was the worst since 1865. There was plenty of fish but no oil. J. Church & Co. caught, in 1876, 200,000 barrels and made over 620,000 gallons of oil. During the year 1877 they caught 183,000 barrels, and only made little over 300,000 gallons of oil. A fish called baracouta drove the menhaden from their usual feeding-grounds, and were absent until they (the baracouta) disappeared; they then put in an appearance, but too late for the factories to do much. The first taken during the summer of 1877 in Maine were from the waters of bays and rivers, and they were less than one-half as fat as they were the year before, when we took them 10 to 15 miles at sea.

"The fishermen usually steam square out to sea, and for the last ten years have found immense beds of them, and apparently inexhaustible amounts, 3 to 4 miles off shore, and generally after about the middle of July they get fat. This year the fat sea-fish could not be found at sea.

"About September 10, the baracoutas left and then they suddenly made their appearance off Portland and vicinity, and at one time the bay between Cape Elizabeth and Wood Island was packed full of the largest and fattest fish that was ever seen on this coast. Our fleet were in the midst of the schools part of two days. A storm came on, and after it was over, they were gone and were not seen afterward. It was about the 1st of October."

The baracouta referred to by Mr. Church is doubtless the tunny or horse-mackerel.

Review of the fisheries of Long Island Sound since 1870, *by Mr. G. W. Miles.*

111. Mr. George W. Miles, of Milford, Conn., for fifteen years engaged in the menhaden fisheries, writes:

"We cannot perceive any diminution in numbers or quantity, but we

do find a great difference at times (and some whole seasons) in size and quality.

"Our usual average catch here in Long Island Sound has been about 8,000,000 per season, beginning June 1, ending October 1. The past season, 1877, our catch was 15,000,000; nearly double the catch of previous years.

"In 1870 there was a large quantity of large fat-fish in the sound; these fish could be seen occasionally several feet under the surface by persons at the mast-head, but could not be seen by the fishermen from the deck of the vessel except occasionally. For some cause, we think they were at the bottom feeding; they did not appear on the surface sufficiently long for the fishermen to catch them until very late in the season.

"On the 10th day of August we had made only 14 barrels of oil. Some of our neighbors, having got discouraged, closed their factories, thinking there would be no catch for the season. At this time the fish suddenly made their appearance on the surface, and were caught in great abundance. They being unusually fat, yielding from 12 to 14 gallons of oil per 1,000, we made in the next six weeks 3,000 barrels prime oil.

"In 1871–'72 there was about the usual quantity of fish, yielding from 4 to 6 gallons of oil per 1,000; an average of several years previous to 1870.

"In 1873 there were immense numbers of small fish from one to two inches long appeared on the surface in the month of September; thousands of shoals could be seen at a time and great numbers in each shoal; these appeared to take possession of all the waters for the remainder of that season.

"In 1874 these small fish appeared again late in the season and were about double the size they were in 1873.

"In 1875 they appeared again much earlier; and in 1876 they came in about the 1st of June, having increased in size and numbers; apparently they occupied the whole waters of the sound, so much so, the larger fish that frequented these waters were actually crowded out of the sound, or left for other waters, and remained off Block Island, at sea, the remainder of the season, and gave up the field to be occupied by the smaller fish.

"The result of this abundance of small fish was a complete failure of the business for the two years 1875 and 1876 in Long Island Sound, the factories and fishing gears having run at great loss.

"In 1877 we provided ourselves with smaller mesh-nets and proceeded to catch the smaller fish, which had now attained a size about two thirds the average here and averaging about one-half pound each. We could catch these by using nets of $2\frac{3}{8}$ inches mesh. They were hardly worth catching, but the men could not stand another season of light catch, and there was no alternative for them; they must catch these or noth-

ing. There was not much oil in them, averaging only from $1\frac{1}{2}$ to 3 gallons per 1,000. Consequently, those manufacturers who carried on a large business barely paid their expenses."

On the coast of New Jersey.

112. At Atlantic City, New Jersey, according to Mr. A. G. Wolf, the mossbunker is the most numerous fish. About 215 barrels were taken in 1873 by Adams & Co., and about the same the previous year. The fishing does not tend to diminish their numbers

At Somers Point, Great Egg Harbor, the mossbunkers are "a thousand fold more numerous" than any other species. In 1873, 7,200 barrels were taken; in 1874, 12,000. Mr. Morris thinks that there is no decrease from fisheries or any other cause.

At Cape May, Mr. D. E. Foster writes they are more numerous than any other fish, but are not so plenty as on the eastern coast of New Jersey. As none are caught in this vicinity, the fisheries are not likely to affect their abundance, nor are they at any point south of Delaware Bay.

On the coast of Delaware.

113. About Bombay Hook, Delaware, according to Mr. J. B. Benson, the oldwife is the most numerous fish in July and August. At Mispillion River, writes Mr. James H. Bell, "they rank equal to, if they are not more abundant than, the sea-trout,* and far exceed any other fish in number: a thousand bushels of trout are sometimes taken at a haul, but the main fishing season does not last over a month, while menhaden are caught more or less during six months of the year. No diminution is noticeable, and the number seems to be about the same one year with another. These fish are not sought in this vicinity for any purpose whatever: they are caught in seines laid for other fish and are left on the beach to rot or taken home to feed hogs, or are composted for fertilizing the soil, for which they are only valuable. The quantity taken from the water never seems to affect the supply."

On the coasts of Maryland and Virginia.

114. In Tangier and Pocomoke Sounds, Maryland, the alewife is the most abundant fish. Mr. Lawson thinks that their number is decreasing from the influence of the fisheries.

At Apateague Island, Accomac County, Virginia, the alewives are more abundant than any other fishes, and are increasing, according to Mr. J. L. Anderton; and this is also the case at Cape Henry, in the opinion of Mr. Richardson.

Mr. H. L. Dudley informs me that a party of New London manufacturers, visiting the Chesapeake in 1866, found menhaden in almost incredible quantities. As he expressed it, "they were so thick that for

* *Cynoscion carolinensis.*

25 miles along the shore there was a solid flip-flap of the northward-swimming fish." One enthusiastic member of the party jumped into the water and with a dip-net threw bushels of fish upon the beach.

On the coast of North Carolina.

115. Mr. Manning writes that at Edenton, North Carolina, these fish are very few.

According to Messrs. Jennett and Simpson the fat-back is by far the most numerous species on the coast of North Carolina. Mr. Simpson writes: "Heretofore the fat-back has been only about one-third more abundant than any other species, but I have seen twice as many during the fishery season of 1873 as I ever saw of any other species on our coast. They are on the increase, and not even their wholesale destruction by the bluefish seems to affect their abundance. About fifty barrels were netted in 1873 at Cape Hatteras. In 1877, in Cape Dare County, about 300 barrels."

"At Beaufort," writes Mr. A. C. Davis, "the menhaden are more abundant than any other species and are increasing; and so it is at Body's Island, North Carolina, where 50,000 barrels were taken in 1868, the fishery having since been discontinued. About 500 barrels were taken in 1877. They are used only for fertilizing purposes."

Mr. Simpson describes their abundance at Cape Hatteras in 1874 in these words: "During the past season the fishermen provided themselves with seines and boats in time to meet the first run of the bluefish. The seines were made of cotton marlin and were about 100 yards long, 2½-inch mesh, and from 40 to 50 meshes deep. The bluefish made their first appearance on the coast from the north. The menhaden passed about three days in advance of the bluefish. I do not think I ever saw so many of this species at any one other time, or at any one other season. From the balcony of the light-house at least 25 schools might have been seen lying along the coast, both north and south of the cape. Each school seemed to cover many hundred yards of surface and to be moving south at the rate of from four to five miles an hour. This continued, and school after school followed, for ten days, before the appearance of the bluefish; and when the bluefish did appear there seemed to be more of the menhaden with them than had passed the station during the three previous days. Hundreds of barrels, I think, were washed ashore and were driven so close by the bluefish that they had not the power to resist the surf, which was quite rough or heavy, and they were consequently thrown ashore upon the beach. Only a very small quantity of these fish were saved, as the fishermen give their attention more particularly to bluefish, but some of them were saved and salted down, when they were sold to a good advantage. Some sold as high (in trade) as to bring ten bushels of corn, equal to $7 in currency, for one common fish-barrel of the menhaden.

"It has been generally thought by old experienced fishermen here,

that the bluefish drive the fatback south in winter, but I have learned differently during the past season from personal observation, which the following fact strongly attests. The menhaden came three days in advance of the bluefish, and entered the sound at all the principal inlets, and made their way directly for the fresh-water rivers. They could be seen as numerous in the sound heading north as they were in the sea heading south. Furthermore, by a letter from a gentleman of Plymouth, N. C., I learn that they passed that place, eight miles above the mouth of the Roanoke, in five days after passing this station; and, by another letter from Windsor, 38 to 40 miles above the entrance, I hear that they arrived there as early as the 18th of December. Thus it may be readily seen that the bluefish are not the cause of the fatback coming south. I would sooner think that the fatback caused the bluefish to come south in winter, as they generally follow in the sea, and among the last of the run of fatback.

"Last year there were not so many of the menhaden, but there were millions of young spot about two years old; but, however, this winter there was not a spot to be seen."

Dr. H. C. Yarrow found enormous schools of very small menhaden about Fort Macon, N. C., December 31, 1871.

Dr. Elliott Coues, U. S. A., states that they appear in great numbers about the harbor at Fort Macon, N. C., in spring and summer.*

On the coast of Florida.

116. In the Saint John's River, Florida, the menhaden are more abundant than any other fish, and apparently on the increase. They clog the shad-nets in the spring.

Summation of evidence.

117. The statements above quoted seem to indicate that the menhaden is by far the most abundant fish on the eastern coast of the United States. There is, moreover, no evidence whatever of any decrease in their numbers. They are apparently quite as abundant as any species on the eastern coast of the United States, not even excepting the cod, herring, and mackerel. There are, however, no data for definite comparison, nor is there any means of determining the ratio of increase or decrease within a given period of years. The same must be said regarding the effects of the wholesale capture going on every year on certain parts of the coast, for the present perfection of fishing apparatus and the skill of the fishermen is likely to prevent any apparent diminution in the yearly returns of the fisheries, even though the species be gradually approaching extinction. It is quite evident that with the improved methods now in use a much larger proportion of the fish frequenting any given body of water may be taken than was formerly possible.

* Notes on the natural history of Fort Macon, N. C. <Proc. Phil. Academy of Natural Sciences.

18.—Abundance in the future.

The probability of future decrease.

118. There is no evidence of a decrease in the abundance of menhaden during a period of fifteen or more years of fisheries conducted on an immense scale. It seems, therefore, that no one can reasonably predict a decrease in the future. The movements of marine fishes are capricious in the extreme. The only cases in which the fisheries have been clearly shown to exercise a pernicious effect is where the spawning fish are taken in great quantities. It has been clearly determined that the menhaden are never captured upon their spawning-beds.

F.—FOOD.

19.—Food of the menhaden.

The opinions of fishermen.

119. Fishermen generally say that the menhaden feed on "brit" and "seed," "red-seed," "cayenne," or "bony-fish feed." These are sailors' names for small floating animals of any kind, such as the minute crustacea, mostly entomostracans (*ostracoda* and *copeopoda*), which swarm the surface of the North Atlantic and are the favorite food of mackerel, herring, and many smaller species. They describe this food as "something of a red or green color and about the size of hay-seed," and very naturally suppose the menhaden to be feeding upon it when they are swimming with their heads at the surface. Others think that they "live by suction," meaning that they feed by drawing through the mouth water containing particles of organic matter. The sturgeons, pipe-fish, and cyprinidæ, all with toothless mouths, are supposed to have this habit. Others say that they feed upon the jelly-fishes (*acalephæ*),* upon the "mossy substance" which clings to the eel-grass (*Zostera marina*), and upon the "scum" or "mucus" which floats on the surface. Perhaps all are right, for most fishes relish changes of diet. At Greenport, N. Y., according to Mr. W. S. Havens, the slimy coating of the eel-grass (which is composed of small algæ, *Spyridia filamentosa*, with various species of *Polysiphonia* and *Ceramium*, &c., often clogged with a soft, slimy deposit) is known as "bunker-feed."

Peculiar movements of the menhaden.

120. Captain Loring has seen the menhaden in Provincetown Harbor in groups of from 20 to 500 gathered among the eel-grass in shoal water, swimming around and around in circles. He supposed them to be spawning, but it seems quite probable that they were feeding. Mr. Hance Lawson states that in Chesapeake Bay the schools break up into small

* Acalephæ do not have the appearance of being nutritious food, but the fattest hogs I have seen in Florida are those at Mayport, which greedily devour a large species of discophore which is cast on the beach in great quantities.

bodies at night, coming in-shore to feed and dispersing into deep water in the morning. Mr. Simpson states that in spring and summer they subsist principally upon mud and scum from the surface of the water, which they obtain by feeding in muddy slues and channels on the ebb, and grassy rivers and shoals on flood-tide.

The examination of stomach-contents.

121. The examination of the stomachs of a hundred or more menhaden, just from the water, taken off Portland, Me., in Block Island Sound, at the mouth of the Potomac, and in the Saint John's River, Fla., has failed to reveal any traces whatever of animal food. Mackerel examined at the same time, in Maine, contained numerous specimens of "seed," which were mostly a large entomostracan (*Irenæus Pattersonii*), and small shrimp (*Thysanopoda*, sp.). Every menhaden stomach which I have opened has been found full of a dark greenish or brownish mud or silt such as is found near the mouths of rivers and on the bottom of still bays and estuaries. When this mud is allowed to stand for a time in clear water, the latter is slightly tinged with green, indicating the presence of chlorophyl, perhaps derived from the green algæ so common on muddy bottoms. A microscopic examination by Dr. Emil Bessels brought to light, in addition to the particles of fine mud, a few common forms of diatoms.*

Inferences from these examinations.

122. Perhaps no decided opinion should be formed without additional data, but the plain inference seems to be that the food of the menhaden, in part at least, is the sediment which gathers upon the bottom of still, protected bays, which is largely composed of organic matter, and upon the vegetation which grows in such water. Upon what they feed during their long sojourn at sea there are no sufficient grounds for conjecture, though it is quite possibly the soft gray ooze and mud which recent explorations of the depths of the Atlantic have shown to exist at every depth, and on the numerous protozoans and *Bathybius*-like substances there flourishing. The peculiar digestive organs of the menhaden were described in paragraph 53.

Professor Verrill on bottom-mud.

123. In remarks upon the characteristics of different deposits of mud, Professor Verrill writes as follows:

"In some cases, especially in well sheltered localities, where the water is tolerably pure, the mud may contain large quantities of living and

* "A large number of specimens [of menhaden] freshly caught in seines were examined, and all were found to have their stomachs filled with *large quantities of dark mud.* They undoubtedly swallow this mud for the sake of the microscopic animal and vegetable organisms that it contains. Their complicated and capacious digestive apparatus seems well adapted for this crude and bulky food." (Prof. A. E. Verrill, in American Naturalist, 1871.)

dead microscopic organisms, both animal and vegetable, and these may even constitute more than one-half of the bulk of the mud, which, in such cases, is peculiarly soft and flocculent; such mud is extremely favorable to many kinds of animals that feed on the microscopic organisms, especially the bivalve shells, holothurians, and many annelids, and the 'menhaden' among fishes. The last variety of bottom, when it has a substratum of sand or gravel a few inches below the surface, is the most favorable kind for oysters, which grow very rapidly and become very fat in such places." *

The evolutions of the schools.

124. Why do the menhaden, when in deep water, swim from morning to night with their mouths at the surface? Perhaps, with their widely expanded jaws and the complicated straining apparatus formed by their gill-rakers they are able to gather nutritious food which is floating on the water. To be convinced that this is possible, one needs only to observe the immense "slicks" of oily matter, often miles in extent, remnants of the bloody feasts which bluefish and bonito have made on other fish, generally the menhaden. An insight into the habit may be gained by watching the menhaden at the head of New Bedford Harbor, near the mouths of the large city sewers. Here a school of these fish is said to be invariably found circling around near the surface with open mouths, apparently in the act of feeding.

Whatever may be the character of their food, their rapid increase in size and oiliness indicates that there is an abundant supply in our waters.

Mr. J. Carson Brevoort states that he has seen menhaden plunging among the floating beds of jelly-fishes. He infers that they feed upon these creatures, though he has not seen the entire act.

The value of menhaden for bait affected by their food.

125. Fish taken in Salem Harbor are not considered good bait. Something in the food which is there obtained renders them very liable to decay, and however carefully they may be packed in ice the viscera soon rot away. A similar phenomenon is well known to the herring fishermen of the coast of Norway, where a certain kind of food, presumably larval forms of small mollusks, often eaten by the herring, causes the fish to decay, in spite of the utmost precaution in salting. It is the custom of these fishermen to keep these fish alive in the nets for several days, to allow them to "work off" this undesirable food. Perhaps a similar precaution might be useful to the Salem Harbor fishing gangs.

G.—REPRODUCTION.

20.—STUDIES OF THE PARENT FISH.

Dissections of Connecticut fish.

126. Of the breeding habits of the menhaden, like those of the bluefish, nothing definite is known. Hundreds of specimens have been ex-

* American Naturalist, 1871.

amined in the north by the naturalists of the Fish Commission, between the months of June and November, and in the south in March and April, without in a single instance discovering matured spawn, so it may be regarded as a demonstrated fact that the species does not breed upon the coast of New England and New York. A large number dissected by me at Noank, Conn., in July and August, 1874, had the ovaries and spermaries partially developed, but still far from maturity, and it seemed probable that three or four months would pass before spawning time.

Others examined at Pine Island, Groton, Conn., October 30, 1877, had the ova more mature, but at least six weeks or two months from perfection, as nearly as I could estimate. The fish then examined were taken in the last runs of the fall, and were supposed to be the Maine schools on their southward migration.

Dissections of Maine fish.

127. Boardman and others state that in the last week in September fish taken in Boothbay had spawn and milt so slightly developed that only persons accustomed to the examination of such subjects could distinguish the sexes.*

The number of eggs in immature ovaries.

128. Hon. S. L. Goodale took the ovaries from a large number of menhaden at Boothbay, September 14, 1876, three to five days before their autumnal departure from the coast. Twelve hundred fishes were examined, and only three were found to contain ovaries which approached

---

* The following letter by Mr. Atkins was received while this report was being printed:

"BUCKSPORT, MAINE, *June* 4, 1878.

"DEAR SIR: I have discovered something about menhaden which is new to me.

"A short time ago a fisherman sent me a menhaden caught in Verona, an adjoining town to Bucksport, which turned out to be a male adult, with well developed spermaries, weighing $\frac{9}{10}$ ounce, the whole fish weighing $11\frac{1}{2}$ ounces; 10 inches long. To-day I have another specimen, also taken in Verona, which turns out to be a female, 11 inches long, with fully developed ovaries, which I have not yet weighed, but which contain eggs a little more than half a millimeter in diameter. I should think they would count out 200,000 or more.

"Another Verona fisherman, Mr. Dudley Abbott, says that last year he slivered a lot of menhaden, and should judge that one-third or one-half of them contained spawn; previous to last year he had seen menhaden with spawn occasionally, but not often he thought; continued to find some such till August last year.

"Mr. Harrison Heath, who sent me the female before me, told me yesterday that he had observed these 'pogies' with spawn for three years past, but did not recollect seeing them before; thought they were plentiest last year.

"You will recollect that I stated to you some months ago that the smelt fishermen reported that last fall they caught considerable numbers of young menhaden of various sizes—small at first and a good deal larger the first of winter—and that it was quite uncommon for so many of them to be taken.

"If these facts are sufficiently interesting, I will endeavor to follow the matter up.

"Very truly, yours,

"C. G. ATKINS."

maturity. These ovaries are deposited in the United States National Museum (Cat. No. 16946). I examined the ripest of them in order to estimate the number of ova. The ovaries with their membranes weighed 17,570 milligrams, or 271.140 grains (0.62 ounce). A portion weighing 420 milligrams was detached. This was found to contain approximately 250 ova, giving to each an average weight of one milligram and eight-tenths. The estimated total number of ova is 9,760, or in round numbers 10,000, which is close enough for all probable necessities. There is no indication of the size of fish from which the ovaries were taken. I am informed by Mr. Milner and Dr. Bean that in the shad and white-fish the number of eggs varies with the weight of the parent. In the latter species a mother fish of one pound weight will yield 20,000 eggs, and one of twice that weight double the number of eggs. This enumeration of the menhaden eggs merely serves to show that, comparatively, the species is not exceedingly prolific.

I am not aware that the number of ova in the ovary of the menhaden has ever before been accurately determined. Mr. Joseph D. Parsons, of Springs, Suffolk County, New York, writes that 70,000 have been counted. Mr. Walter Wells, of Portland, Me., states that he has somewhere heard of two millions having been counted. Several writers have lately expatiated on the immense fecundity of the menhaden. This has not yet been established.

No mature ova have been observed.

129. From Maine to Florida there can be found very little satisfactory evidence that spawn fully ripe has been seen, or that spawn or milt ever has been observed to run from the fish when handled after capture.

An instructive circumstance is mentioned by Mr. Bell, of Mispillion River, Delaware Bay, who states that after the last of these fish had disappeared from those waters, about the 7th of November, 1874, the bay from Cape May to Cape Henlopen and eighteen miles above its mouth was crowded with the largest menhaden ever seen on the coast, many of them equaling a medium-sized shad, and nearly three-fourths of them pregnant with large and nearly matured roe. They had been driven in by the bluefish which destroyed and pursued them ashore in vast numbers. Sixty hours after the arrival of the menhaden not one was to be found on the coast.

According to Captain Atwood, of Provincetown, some menhaden taken at that place in December had mature spawn.* He suggests that these fish, which were very few in number, may have been detained in the creeks by accident.

A statement by Mr. Atkins.

130. Boardman and Atkins, apparently quoting from Mr. George B. Kenniston, state that off the coast of Virginia, about Christmas, the

* Proceedings of the Boston Society of Natural History, vol. x, p. 67.

females can be readily distinguished by the distension of the abdomen; both sexes are so ripe that eggs and milt can be easily pressed from them. In Chesapeake Bay, in early spring, just after the advent of the adult fish, great schools of the young are seen, thought to be one and a half or two inches long. These little ones huddle together in dense schools, preyed upon by shovel-nosed sharks and other enemies. They are bound, so far as can be seen, in no particular direction, and are not supposed to come further north, but to pass the summer there and leave in the fall greatly increased in size. The color of these young fish, when seen in mass, is black, instead of red, which is the color of a school of adults when seen beneath the surface. These statements are not authenticated by the name of the observer, and must be received with caution.

21.—Studies of the young fish.

The young fish in Southern New England.

131. Young fish from four to six inches long make their appearance in vast numbers a few weeks after the arrival of the adult fish. So extensive are the schools that experienced fishermen are sometimes deceived, mistaking them for schools of large fish, and make every preparation for setting their nets. These little fish play up into the shallow coves and the brackish water at the mouths of rivers and become an easy prey to small bluefish, eels, flatfish, and other small fishes.

Young menhaden seldom round Cape Cod, though they are not uncommon in Provincetown Harbor in September, where the fishermen catch them in dip-nets for bait. They have never been seen on the coast of Maine. Mr. Dodge states that they are occasionally seen in coves near Marblehead, Mass., and Mr. Babson has seen schools of half-grown fish at rare intervals about Cape Ann. In the museum of the Peabody Academy of Sciences, at Salem, is a bottle containing specimens about three inches long taken in Salem Harbor. South of Cape Cod, as far as Cape Hatteras, they swarm in the waters in late summer and autumn, and in the Saint John's River, Florida, the creeks and coves are alive with them in summer and early autumn. In the harbor of Beaufort, S. C., they are said to occur in December.

These schools of small fish, some of them little over an inch in length, suddenly make their appearance in the bays of the Vineyard and Fisher's Island Sounds about the middle of August. It may be regarded as certain that they are not hatched from the eggs in these localities, because for several seasons the ground has been thoroughly explored daily for two months before the appearance of these fish without finding a trace of fish of smaller size.

Locomotive powers of the young menhaden.

132. It has been suggested that young menhaden, less than two inches in length, cannot be thought to have traveled from the Virginia coast, a

distance of three hundred miles, nor even fifty miles, and from this it is argued that some of the species must spawn not far from the Vineyard Sound. It is not impossible that this conclusion may be true, still the premises are hardly sufficient. The young menhaden at the time of their first appearance on the southern coast of Massachusetts are strong and active, and apparently fully developed in bone and muscle. There is no apparent reason why they might not make long journeys.

22.—Inferences as to time and place of spawning.

The testimony of young and parent fish.

133. Certain inferences may perhaps be drawn from the facts mentioned above. The menhaden taken in summer and early autumn on the coast of New England show ovaries and spermaries in an undeveloped state, but evidently slowly approaching maturity, while others accidently delayed in Cape Cod Bay and Delaware Bay show in November spawn nearly ripe and in December ova quite mature. In October the southward migration begins, and by the 1st of December they have deserted the coasts of the Northern and Middle States. These schools winter, in part, on the coast of North Carolina, where they arrive in large numbers from the last of November to the middle of December, and are also found throughout the winter on the coast of Florida. The young fish, from one to three inches in length and upward, are common throughout the summer on the southern coasts, and those of a larger growth, from five to eight inches, occur in late summer and autumn on the coast of Southern New England south of Cape Cod. There is no satisfactory evidence that spawning takes place in the rivers of the Southern States. Will not these considerations warrant the hypothesis that the breeding-grounds of the menhaden are on shoals along the coast, from North Carolina, and perhaps Florida, northward as far perhaps as Virginia or New Jersey? This idea was first advanced by Captain Atwood and has received the sanction of Messrs. Goodale and Atkins.

The opinions of fishermen.

134. The majority of intelligent fishermen in the North seem to believe that the menhaden is a winter spawner, breeding in Southern waters, though some, arguing from the presence of small fish in autumn, advance the idea that they spawn in Long Island Sound and Narragansett Bay, while others still think it probable that there are two spawning seasons, one at the north in the summer and another in the winter at the south. I have been assured by several fishermen that when seining menhaden they have found a mass of their spawn, two or three feet in diameter, carried in the center of the school, and the idea was advanced that the fish transported and in this way cared for their eggs until they should be hatched.

I have had the opportunity of examining one of these supposed

masses of menhaden spawn, which proved to be a cluster of squid (*Loligo Pealii*) eggs, and it is probable that these singular objects have given rise to all similar stories.

A claim that menhaden spawn in Southern rivers.

135. The young menhaden which frequent the coasts north of the Carolinas are usually four or five inches in length, and there is no record of their having been seen of a less size than three inches, and these are probably the fish hatched from the eggs during the winter, which, in obedience to the migratory instinct, move northward along the coast. The movements of the schools of young resemble in every respect those of the grown fish, and they approach the shore from deep water by the same routes. At Cape Hatteras, according to Mr. Simpson, the young fish from one inch upward are seen throughout the summer, which points clearly to a proximity to the spawning-ground at that point. In the Saint John's River they are found two inches in length. It is the opinion of Mr. Kemps that many of the menhaden spawn in the river, and he is positive that he has seen spawn running from the fish taken in the early part of the year. The presence of the young fish in the waters, however, does not necessarily point to that conclusion, as he very naturally supposes it to do.

Mr. Simpson believes them to spawn in the Neuse River, but this is not proven to be a true supposition.

Criticism of a statement by Professor Hind.

136. In this connection I must call attention to a misapprehension on the part of my friend Professor Hind, who, basing his conclusions upon some uncollated returns in Professor Baird's first report, states that the spawning period of the menhaden is in the spring, at which time it appears to come from its winter home in the deeper waters off the coast to the shores, at dates corresponding to those of others whose movements are governed by temperatures.* And again he states, without citing any authority, that "following the law which govern fish life, its mode of spawning resembles that of the typical herring." This may or may not be true. No one knows.

23.—THE FEASIBILITY OF ARTIFICIAL CULTURE.

A claim that menhaden may be acclimated in Northern waters.

137. In a report to the minister of marine and fisheries, Mr. J. G. Whiteaves remarks: "It would perhaps be desirable to try and acclimatize menhaden in British waters. All that would be necessary would be to send a vessel or two, each provided with well-room, to the United States, and liberate the menhaden thence procured at the mouth of any of the New Brunswick or Nova Scotia rivers, such as Saint Andrew's

* The effect of the fishery clauses of the Treaty of Washington, &c., 1877, p. 73.

Bay, L'Etang, Lepreaux, or Musquash, in New Brunswick, or Saint Mary's Bay and its tributaries, or Tusket River, in Nova Scotia."*

In his report for 1873, Mr. Peter Mitchell, minister of marine and fisheries, announces that he intends to suggest the artificial production of bait for the deep-sea fisheries on some part of the coast of Nova Scotia, and to devote attention especially to the growth of the menhaden and other bait-fishes of that class.†

In the "Case of Her Majesty's Government," before the Halifax Commission (see below in paragraph 219), the claim is made that "the menhaden bait itself can be bred and restored to places in the Bay of Fundy on the coast of Nova Scotia, where it existed up to the time of its extermination."

With regard to these claims it can only be said that they are untrue and unsound. No one having the slightest acquaintance with the principles of fish culture would entertain the idea of the feasibility of such schemes.

H.—ENEMIES AND FATALITIES.

24.—DISEASES.

Mortality in the Merrimac River.

138. Capt. Moses Pettingell tells me that great mortality often prevails among the menhaden at the mouth of the Merrimac River. In 1876 the dead fish were heaped upon the shore to a depth of two feet, and the municipal authorities of Newburyport expended a large sum of money in carting them away. The fish seem to die in great pain; they come first to the surface, then, after a severe flurry, die. They sink immediately to the bottom, but float at the surface after a day or two.

It is stated that the same mortality prevailed forty years ago as now among the mendaden in the Merrimac. They covered the shores, tainted the air, and were taken away by the farmers as dressing for land. It was noticed that the fish would come to the surface, spin around and around, and then turn over on the back and die.‡ These strange deaths are very probably caused by the presence of some internal parasite.

25.—PARASITES OF THE MENHADEN.

The crustacean, Cymothoa prægustator.

139. Some of the parasites which infest the menhaden are particularly curious and interesting.

The name "bug-fish," commonly applied to the menhaden in the Southern States, has reference to a large parasitic crustacean frequently

* Sixth Annual Report of the Department of Marine and Fisheries, 1874, appendices of the fisheries branch, p. 196.

† Fifth Annual Report, &c., p. 66.

‡ Springfield Republican, August 21, 1871.

found in the mouth of this fish. This parasite appears to have been first described by Latrobe, who proposed for it the name *Oniscus prægustator*.* Say subsequently referred it to the genus, *Cymothoa*.† It is known to the fishermen as the "bug," "fish-louse," or "crab-louse," and belongs to the order of Isopoda or equal-footed crustaceans, familiar examples of which are the whale-lice (*Cyamus ceti*, &c.) and the boring shrimps (*Limnoria lignorum*) which riddle so completely the planks of ships and other submerged timbers, or, better still, the "wood-lice," "saw-bugs," or "pill-bugs" to be found in any old cellar or wall and under stones and logs which have lain for a time on damp ground. Verrill and Smith ‡ give twenty-three marine species for the coast of Southern New England. Most of these inhabit the rocky shores, clinging to the roots and branches of rock-weed or crawling among the rocks near high-water mark. Three are parasitic, one upon the bluefish, one upon the orange filefish; a third was found by Professor Leidy in the gill cavity of a hermit-crab (*Gelasimus pugilator*). *Cymothoa prægustator* § resembles in its shape a large "pill-bug," the females reaching the length of two inches, the males somewhat smaller; they are provided with seven pairs of legs, with claws sharply pointed and adapted for clinging to their protector; their color is dirty white. The females carry their eggs in a large pouch on the under side of the body, formed by a series of large scaly plates, where they are retained until the young are hatched and large enough to care for themselves. The *Cymothoa* is not in any true sense of the word a parasite, drawing nourishment from the fish to which it attaches itself; it is commensal, stealing shelter and transportation, but not subsistence, and Latrobe was very happy in his selection of a specific name, for a Roman *prægustator* was a foretaster, a cup-bearer, one who tasted the meats and drinks before they were served on the table of a prince. Clinging with its hook-like claws to the roof of the menhaden's mouth, its back downward, its mouth in close proximity to the front of the fish's upper jaw, it is in a very favorable location to take toll from every mouthful of food which passes into the brevoortian throat. It may change its quarters at will, and when the fish is dead frequently relaxes its grasp and crawls out of the mouth. Latrobe writes: "I have sometimes succeeded in taking out the insect in a brisk and lively state, but as soon as he was set free he immediately scrambled back into the mouth of the fish and resumed his position." The presence of so bulky a guest must greatly inconvenience the menhaden. I have taken from the mouth of a fish nine inches long two of these crustaceans, a male three-fourths of an inch long, and a female measuring an inch and three-

* A drawing and description of the Clupea Tyrannus and Oniscus Prægustator. By Benjamin Henry Latrobe, F. A. P. S. Transactions of the American Philosophical Society held at Philadelphia, for promoting useful knowledge. Vol. V., 1802, p. 77, pl. 1

† Journal of the Academy of Natural Sciences of Philadelphia, Vol. 1., part II, 1818 p. 395.

‡ Report of the Commissioner of Fish and Fisheries for 1871–'72, p. 567.

§ See plate X.

quarters, the vertical diameter of whose body, with distended egg-pouch, was a half-inch; this pair of lodgers completely filled the mouth of the fish, and must have incommoded him in the act of feeding. Aside from inconveniences of this nature, the presence of the parasite does not appear to affect the well-being of the fish, those whose mouths are tenanted seeming as plump and healthy as those having apartments to let.

About seventy per cent. of the menhaden from the Potomac examined by me in November, 1874, had the *Cymothoa* in their mouths, and even a larger proportion of those in the Saint John's, in April, 1875. Say states that a large number of those in the Delaware were thus infested, and Mr. F. C. Goode writes that this is the case in the Saint John's River, Florida. The thirty-first question of the "Menhaden Circular" issued by the Commissioner of Fisheries was intended to draw out information on this point, and, from the statements of correspondents, in reply to this query, we may quite definitely conclude that this parasite of the menhaden is unknown in northern waters. Mr. A. G. Wolf, keeper of Absecum light, New Jersey, writes that a "bug" is sometimes found in the roof of the mossbunker's mouth, and almost every correspondent from localities south of that point notices its occurrence. On the other hand, it has never been observed in the waters of New England and New York. I have examined many specimens from Long Island and Block Island Sounds without finding it, and Prof. S. I. Smith tells me that his search for it in the vicinity of Great Egg Harbor, New Jersey, was equally unsuccessful. In Chesapeake Bay and the Potomac, in the Delaware River and Bay, in the inlets of North Carolina, and the Saint John's River, Florida, it is well known as the companion of the alewife or fat-back.

Capt. Robert H. Hulbert, in the latter part of May or early in June, while seining mackerel from the Ellen M. Adams, of Gloucester, near Block Island, took, with the mackerel, about a barrel of large menhaden, most of which had the parasite in their mouths. At this time most of the menhaden had gone farther north. The later a school comes in, the faster it runs to the northward, says Captain Hulbert.

Inferences to be drawn from the presence of this parasite.

140. It is not known whether *Cymothoa prægustator* is a constant companion of the menhaden, accompanying it in its migrations and dependent upon it for existence, or whether it simply seeks shelter in the mouth of the fish at a particular season of the year. Is it not possible that it may be free during a part of its life, seeking shelter perhaps during the breeding season? Latrobe found it parasitic in March; my observations were made in November. It is very important that the chasm between these dates should be bridged, for whatever the truth may be, it will throw much light upon the migrations of the menhaden. If it be a constant parasite, the presumption will be that the schools of fish which frequent the shores of the Southern States, during the summer, do not in their

winter migration come in contact with the schools from the north, otherwise the parasites would naturally be communicated. If it inhabits the mouths of the fish only while they remain inshore, and has therefore a fixed faunal relation to certain parts of the coast, it may be concluded that the menhaden of particular schools are like, the anadromous fishes, restricted to particular portions of the coast, and that those schools which enter the southern inlets in spring do not proceed farther north in their migration, but remain in those localities throughout the season. Still other conclusions may be forced upon the investigator: it may be that the adult *Cymothoa* never quits its position in the mouth of the fish, and that the young only swim about in search of unoccupied quarters, and in this case it need not necessarily follow that the parasite would be communicated by southern to northern fish if they were to find their winter homes in the same waters. The study of this curious parasite and its habits will at any rate prove interesting and instructive.*

Other parasites.

141. The menhaden seems remarkably free from other parasites, and especially from intestinal worms, not one of which has been met with in numerous dissections. Leeches are occasionally found upon the gills, and there are one or more species of lernæans. Mr. Hance Lawson, of Crisfield, Md., refers to one of these, saying that "there is a five-pronged insect sometimes found on the tail which makes a sore and which we call grappling"—a name doubtless referring to its shape, which might call to mind a grappling-iron; several other correspondents refer to a parasite which is unmistakably a lernæan.

I know of only one described species of crustacean parasitic upon the species, and this is found also upon the alewife. It is the *Lerneonema radiata* (Lesueur) Stp. and Ltk., first described in 1828. It is found figured in the first report of the United States Commissioner of Fisheries, plate VII, Fig. 30, and below, plate X.

26.—Predaceous foes.

Whales and dolphins.

142. Man, with his instruments for wholesale destruction, takes six or seven hundred millions of these fish annually, but he is only one of its many enemies. Whales follow the schools and consume them in great numbers. Mr. E. B. Phillips states that fin-back and hump-back whales always appear in Massachusetts Bay when the menhaden come. According to Capt. John Grant, keeper of the light-house on Matinicus Rock, Maine, "The whale rises beneath them as they play upon the surface and, with extended jaws, forces himself up through the school with such speed as to project his body half out of water, closing his jaws over large quantities of fish as he falls heavily back."

* This paragraph was written two years before paragraphs 84–91.

Mitchill remarks: "The whalemen say he is the favorite food of the great bone-whale or *Balæna mysticetus.* This creature, opening his mouth amid a school of menhaden, receives into its cavity the amount of some hogsheads of menhaden at a gulp. These pass one by one head foremost down his narrow gullet; and eye-witnesses have assured me that on cutting up whales after death great quantities of menhaden had been discovered thus regularly disposed in the stomach and intestines."*

I have seen fin-back whales apparently feeding in this way at the eastern end of Long Island Sound. Schools of dolphins and porpoises follow the menhaden, consuming them in immense numbers, and seals are said to be among their persecutors.

Mr. Dudley informs me that in 1877 the fish left the sound on the 12th of October; on the 19th enormous quantities were driven back by a school of 30 or 40 whales which the fishermen saw playing off shore.

Sharks.

143. Sharks prey largely upon the menhaden. Capt. B. H. Sisson has seen 100 taken from the stomach of one shark. Mr. D. T. Church gives an account of the destruction of a school off Seaconnet, R. I. "They were lying," he writes, "apparently undisturbed, when a school of sharks appeared among them. The havoc was fearful. One gang of fishermen had their seine in the water at the time, and they completely destroyed it; they were so ugly that they would seize the end of an oar as if it were a fish."

Mr. E. E. Taylor, of Newport, R. I., gives an amusing account of the habits of the thresher shark (*Alopias vulpes*): "The heaviest shark we have around here is the thresher shark; they feed on menhaden. I saw a thresher shark kill with his tail, which was nearly eight feet long, half a bushel of menhaden at one blow, and then he picked them up off the water. They come up tail first, and give about two slams, and it is "good-by, John,' to about half a bushel of menhaden."† This story should be taken *cum grano salis*, but still may contain a few grains of truth.

The horned dog-fish (*Squalus americanus*) and the smooth dog-fish (*Mustelus lævis*), the smallest representatives in our waters of the shark family, doubtless do more injury than their larger brethren by reason of their great abundance. The former are so voracious that when they make their appearance all other fishes are driven away. When the dog-fish "strike on," an experienced fisherman always pulls in his lines or his nets and abandons his work.

Other fishes.

144. All the large carnivorous fishes prey on the menhaden. The horse-mackerel or tunny (*Orcynus thynnus*) is one of the most destruc-

* Trans. N. Y. Lit. and Phil. Soc., 1, 1815, 453.

† Report of Commissioner of Fish and Fisheries, 1871–'72, p. 28.

tive in certain localities. "I have often," writes Mr. George R. Allen, of Brooklin, Me., "observed these pests, with the most imaginable indignation, in their destruction of these fish, and watched their antics from the masthead of my vessel, rushing and thrashing like demons among a school of fish, darting with almost lightning swiftness through them, scattering them in every direction, and throwing hundreds into the air with their tails." This is doubtless the barracoutar spoken of by Maine fishermen.

Boardman and Atkins accuse the pollock (*Pollachius carbonarius*) and the whiting or silver hake (*Merlucius bilinearis*) of much damage done. In reference to the latter they write: "It is known to pursue both herring and menhaden. The former it devours in great numbers, and at Grand Manan a great many of the smaller ones are sometimes caught in the herring-nets. In Bluehill Bay, in Kennebec River, and doubtless in other places, it is caught in the weirs, and the Brooklin fishermen often take it in their seines with menhaden. Its teeth are rather long and remarkably sharp, and they are charged with wounding a good many menhaden which are afterward caught with their sides and backs lacerated as if in that way."*

The striped bass (*Roccus lineatus*) is destructive, and so is the squeteague or weakfish (*Cynoscion regalis*) and its southern representative, the spotted squeteague or so-called "sea trout" (*Cynoscion carolinensis.*†) I have found a menhaden a foot in length in the stomach of a squeteague.

In the southern rivers the gar-fish (*Lepidosteus osseus*), the "trout" (*Micropterus nigricans*), and the cat-fishes (*Siluridæ*) with the tarpum, (*Megalops thrissoides*), are said to be its worst enemies. I have found menhaden to be the only thing in the stomachs of specimens of the latter species, taken on the northern coast in summer, and it is probable that these were attracted from their usual haunts in pursuit of their favorite food. The sword-fish (*Xiphias gladius*) destroys many, rushing through the masses of fish, striking right and left with its powerful weapons. From examination of their stomachs it would appear that the bayonet-fish (*Tetrapturus albidus*) also feeds extensively upon them. The codfish is said to eat many of them, and this seems quite probable, for these fish bite freely at a menhaden bait.

The bluefish and the bonito.

145. The bluefish (*Pomatomus saltatrix*) with the bonito (*Pelamys sarda*) are, however, their most destructive enemies, not even excepting man. Mr. Simpson, examining a great many of the bluefish caught on the North Carolina coast in the summer of 1874, found from one to three "fatbacks" in the stomach of each. These corsairs of the sea, not content with what they eat, which is of itself an enormous quantity, rush

* Op. cit., p. 14.

† A southern correspondent speaks of finding eight menhaden in the stomach of one sea trout.

ravenously through the closely crowded schools, cutting and tearing the living fish as they go, and leaving in their wake the mangled fragments. Traces of the carnage remain for weeks in the great "slicks" of oil so commonly seen on smooth water during the summer season.

Menhaden driven ashore.

146. The terrified fish fly in every direction, and are often driven ashore in great numbers. Mr. Church states that the bluefish sometimes come into Massachusetts and Narragansett Bays in such force as to completely exterminate the menhaden, driving them ashore in great numbers.

Mr. James H. Bell, keeper of Mispillion River Light, Delaware Bay, writes that about November 7, 1874, the shores of the bay from Lewes up to Mispillion River were lined with dead fish, bitten to death by the bluefish, or snapping mackerel as it is there called. Many of the dead fish were without tails, and all were more or less mutilated. Many other cases may be mentioned where the fish were thus floated ashore, but whether their death is to be traced to the persecutions of the bluefish or to some epidemic prevailing at the time can never be certainly known.

Mr. David F. Loring, keeper of Highland Light, Truro, Mass., has seen hundreds of barrels of them cumbering the shore in the western part of Provincetown Harbor, driven up by bluefish, and has also seen them thrown ashore in numbers at the mouth of the Merrimac River.

About 1856 they were thrown up on the coast of Maine in such quantities that the people in the vicinity were obliged to bury them as a sanitary measure.

Capt. Joseph Hardy second, light-house keeper at Chatham, Mass., states that in 1832 they drifted ashore on the southeastern point of Cape Cod in such numbers that the inhabitants were summoned to bury them in pits, for fear of a pestilence, and that the same thing occurred a few years later.

Mr. B. Lillingston, of Stratford, states that large numbers are sometimes washed up along the coast of Connecticut in September and October. Mr. F. Lillingston, of the same place, has seen thousands dead upon the shore, some with "a reddish blotched appearance, others eaten as if by cancer." According to Mr. Albert Morris, they floated ashore by tons at Somers Point, New Jersey, in October, 1873.

Mr. Isaac D. Robbins, keeper of Hog Island light station, Maryland, states that in August, 1852, he saw a great many dead ones, about two inches in length, in Swangut Creek, on the Eastern Shore, near the line between Maryland and Virginia. He attributes their death to the effects of the warm weather.

According to Mr. Wallace R. Jennett, they have sometimes drifted ashore on Cape Hatteras in such abundance that the stench of the decomposing mass was almost unendurable.

Capt. David Kemps, of Yellow Bluffs, Fla., writes that about the year 1870 the menhaden in the Saint John's River died in large numbers and were washed ashore upon the banks.

The Newport (R. I.) Daily News of June 13, 1870, states: "Millions of fish, principally menhaden, scup, and young shad, have been driven on to the New Jersey and Long Island shores the past week. Coves, rivers, flats, inlets, and ditches have been so full that farmers have gathered them up by the common pitchforks and shovels, carrying off thousands of cart-loads to manure the land. It is supposed that these schools of small fry were driven inshore by the bluefish."

Mr. Phillips has known them driven by the bluefish up the great rivers of Maine until they died and were washed ashore by thousands.

Captain Spindel on the ravages of the bluefish.

147. Capt. Isaiah Spindel, manager of a fish-pound at the eastern extremity of Buzzard's Bay, states: "I do not think pound-fishing is a quarter as bad as bluefish for destroying fish. A bluefish will destroy a thousand fish in a day. When they get into a school of menhaden you can see a stream of blood as far as you can see. They go into them and they will destroy the whole school before they let them go. I think menhaden are more scarce than they used to be. They put up the guano factory here (at Wood's Holl) on account of menhaden being so plenty then. Twenty-five or thirty years ago there were no bluefish, and menhaden were plenty. Only once in a while were there any bluefish there. Finally the bluefish got so plenty they drove all the menhaden out of the bay. There are plenty of menhaden up in the heads of the harbors; some bluefish will go up and drive them up as far as they can, but bluefish don't like to go up into fresh water. Squeteague will swallow menhaden whole. I have seen bluefish and squeteague throw the food out of their stomachs when caught. I think the bluefish fill their stomachs and then empty them just for the fun of the thing, so as to catch more fish. I have seen them go into a school of menhaden and catch some and throw them up again, and then go in again. I could not swear they throw the stuff up, but I am positive that it is so. I have seen the fish all chewed up thrown out in the water. They often bite and swallow a part and leave the rest."*

Professor Baird on the destructiveness of the bluefish.

148. Professor Baird, in his well-known and often-quoted estimates of the amount of food annually consumed by the bluefish,† states that probably ten thousand millions of fish, or twenty-five hundred millions of

* Testimony in regard to the present condition of the fisheries, taken in 1871. <Report of the United States Commissioner of Fish and Fisheries, 1871–'72, pp. 68–70.

† Natural History of Important Food-Fishes of the south shore of New England. II.—The Bluefish (*Pomatomus saltatrix,* (Linn.) Gill. Report of United States Commissioner of Fish and Fisheries, 1871–'2, p. 241–'2.

pounds, daily, or twelve hundred million millions of fish and three hundred thousand millions of pounds annually, are much below the real figures. This estimate is for the period of four months in the middle of the summer and fall, and for the coast of New England only. The calculation allows ten fish, or two and one-half pounds, daily, to each bluefish, and estimates the number of these corsairs of the sea in New England waters at one thousand million. This calculation includes only those fish which exceed three pounds in weight, taking no account of those of a smaller size, which are at least a hundred-fold more numerous, and fully as voracious, and which prey upon the young fish.

Such estimates profess to be nothing more than vague approximations, but are legitimate in their way, enabling us to appreciate more clearly the luxuriance of marine life. The application of similar methods of calculation to the menhaden would be much more difficult. At least one-fourth of the fish devoured by bluefish on the shores of New England are probably menhaden, and as many more are no doubt destroyed by squeteague, bonito, sharks, horse-mackerel, cod, and other predaceous species. The waters of New England wash only one-fourth of the extent of coast upon which the menhaden is abundant, and the estimate of Professor Baird covers only one-fourth of the entire year. Bluefish are abundant for at least half the year as far south as the Carolinas, and commit terrible havoc among the menhaden in the winter months. Farther south they are the favorite food of other species, chief among which are the sea-trout (*Cynoscion carolinensis*). Then there are the schools of porpoises and the whales, which pursue the herded menhaden with wholesale destruction.

An estimate of the annual destruction of menhaden.

149. Is it too much, then, to multiply the three hundred millions of millions of menhaden probably consumed by the full-grown bluefish alone on the coast of New England in the summer months by ten? This would allow three thousand millions of millions of menhaden, old and young, annually destroyed in the waters of the United States, in comparison with which the number annually taken by man is perfectly insignificant. This estimate will seem extravagant at first sight, but I believe that it will be found a very moderate one by any who may take the pains to investigate the question for themselves.

The place of the menhaden in nature.

150. It is not hard to surmise the menhaden's place in nature; swarming our waters in countless myriads, swimming in closely-packed, unwieldy masses, helpless as flocks of sheep, close to the surface and at the mercy of any enemy, destitute of means of defense or offense, their mission is unmistakably to be eaten. In the economy of nature certain orders of terrestrial animals, feeding entirely upon vegetable sub-

stances, seem intended for one purpose—to elaborate simpler materials into the nitrogenous substances necessary for the food of other animals which are wholly or in part carnivorous in their diet. So the menhaden, deriving its own subsistence from otherwise unutilized organic matter, is pre-eminently a meat-producing machine. Man takes from the water annually six or seven hundred millions of these fish, weighing from two hundred and fifty to three hundred thousand tons, but his indebtedness to the menhaden does not end here. When he brings upon his table bluefish, bonitos, weakfish, swordfish, bass, codfish, what is he eating? Usually nothing but menhaden!

27.—MAN AND THE FISHERIES.

Former allusions to the influence of the fisheries.

151. I have remarked above (paragraph 117) that the menhaden appears to be the most abundant species on the eastern coast of the United States, and that there is no evidence of any permanent decrease in its numbers, although from year to year there are fluctuations in their numerical representation.

I have also discussed (paragraph 102) the question of the alleged change in their habits from the tendency of seine-fishing to drive them farther from this coast. Upon this question there can be no decided judgment at present. In paragraph 118, I have spoken of the slight probability of decrease in future.

Future increase or decrease.

152. Whether there is any likelihood that the myriads which now swarm our waters will ever be perceptibly diminished by the loss of six or seven hundred millions of their number annually I will not presume to say. I simply call attention to the fact that spawning fish are apparently never taken in the nets. It is the opinion of many authorities that if fish are not interfered with at the time when they are reproducing their kind there is no great probability of decreasing their number.

Alleged destruction of the fisheries.

153. The Commissioners of Fisheries of the State of New York, Messrs. Horatio Seymour, Edward M. Smith, and Robert B. Roosevelt, in their report for the year 1874* (p. 31), speaking of the depletion of the waters of Great South Bay, remark:

"Last season was favorable for the pound-fishermen, in the circumstance that the sharks did not destroy their nets. The result was, that there was absolutely no fishing inside the bay the entire summer. Usually, by the month of August, they have to move from the inlet to

* Report | of the | Commissioners of Fisheries | of the | State of New York. | —— | Transmitted to the legislature, February 1, 1875. | —— | Albany: | Weed, Parsons and Company, Printers. | 1875. | 8vo. pp. 61.

safer quarters, and the weakfish get in sufficiently to furnish fair fishing, and to promise a continuance of the supply. But that year the pounds remained undisturbed, and not even the weakfish could find an entrance. Formerly moss-bunkers, or bonyfish which are manufactured into oil and manure, frequented the bay and brought bluefish after them. They are the favorite food of the latter. They have been the foundation for quite a business in that part of our State, a number of factories having been established along the shore. Now they are never taken inside the bay, and the bluefish, whether for the reason that their food is wanted, or on account of their natural shyness, are also rarely seen inside. The latter are still caught in seines at some of the inlets, but seem to be stopped by the pound-nets, or else return of their own accord to the ocean. They do not enter the pound-nets, being seldom taken in them. This would go to show that they are frightened away; that when they meet the wings of the net they do not attempt to pass around it, but simply retrace their steps to safer quarters. The loss thus inflicted on the residents along the bay, without benefit to any one, is incalculable."

Comments upon these allegations.

154. It is the commonly received opinion that purse-net fishing is destined eventually to destroy all the menhaden in our waters. Many decided views to this effect have been advanced by correspondents. All that can be said at present is that the commonly received opinion has not yet been proved to be true. The same may be said regarding pound-net fishing. It is doubtless true that the fisheries in a given locality may deplete the waters of the immediate region in which they are prosecuted. The cod and halibut may be fished for upon a single bank until the local supply is exhausted. This depletion does not, however, necessarily affect the aggregate numbers upon the entire coast.

The barrier of pounds will doubtless prevent the menhaden from entering a body of water like the Great South Bay, but this does not necessarily have any effect upon the aggregate representation of the species in the coast waters. The small number of fish consumed by man proportionately to the number consumed by other fishes has been alluded to.

A writer in Chambers's Journal estimates the herring-eating power of the Solan goose as follows: "Say that the island of St. Kilda has a population of 200,000 of these birds, and they feed there for seven months; let us also suppose that each bird, or its young ones, eat only five herrings per diem; that gives a sum total of one million of these fish, and counting the days in the seven months from March to September as 214, that figure may be taken to represent in millions the quantity of herrings annually devoured by these birds. It has been calculated that the cod and ling in the seas and friths around Scotland would devour more herrings than could be caught by 50,000 fishermen. We have examined the internal economy of a codfish, which contained in its stomach no less than eleven full grown herrings."

Professor Hind's unwarranted statements.

155. A voice of warning comes to us from the provinces. Professor Hind writes: "It is not the fishermen alone who diminish the value of the waters of the United States as food producers, it is the agriculturist, the manufacturer, and the lumberer. If the supplies directly or indirectly afforded by British-American coastal fisheries were suddenly annihilated, the effect of the inquiries instituted under the direction of the United States Commissioner of Fish and Fisheries would be at once diverted against the fish-oil and fish-guano manufacturers as well as the lumbering and other interests, which have so diminished the anadromous species and destroyed the cod-fisheries on the New England coast. What with the ravages of the bluefish and the demands of the industrial interests named, the drain upon the United States waters is far beyond the natural resources of the limited area in which the cod, the hake, the halibut, and other deep-sea fish are sought. Hence recourse must be had to British-American waters or the open sea remote from the coast of the United States, and bait must be obtained to secure remunerative fares. Without this bait the fishery would be commercially impossible; with it, it becomes not only renumerative, but permits those special fisheries which have fish-oil and fish-guano as their object to go on without that legislative interference which would otherwise be invoked by a powerful interest contemplating impending ruin and discerning its cause."*

Comment is unnecessary. The facts above stated alone are a sufficient commentary.

Protective legislation in Maine.

156. As this memoir goes to press, the question of legislative restrictions of the menhaden fisheries is being agitated in Maine. One of the valuable results of this discussion has been the publication of Mr. Maddock's report upon "The Menhaden Fishery of Maine," which is intended to counteract the statements of the advocates of more stringent laws. The proposed law is intended to prohibit fishing with seines in waters within three miles of the shore. Mr. Maddock's remarks, quoted below, seem very sensible and temperate, and I am prepared to indorse them:

"In fact, where all the data point to the conclusion that the menhaden while on our coast are being destroyed by predaceous enemies in greater numbers every day than by man with all his appliances in a whole season, it would seem sheer unreason to establish a petty restriction of the catch lest the stock should be ultimately exhausted.

"No other State will be guilty of such folly, even if we should allow our own to be. The effect of restricting the fishery, as referred to, would be to drive the oil and guano manufacture and those engaged in it out of the State, with all their capital and equipment, and to extinguish the industrial activities set in operation by their business. The time for

*Hind, *op. cit.*, p. 142.

restriction will be when restriction has been shown to be needed. Other States have made a trial of the interference policy in this same matter and have abandoned it as uncalled for and unwise.

"The complaint that the seines 'scare' the edible fish from the interior waters may be dismissed as too trivial for notice. If the limited operations of seining inshore scare the fish out, much more should the far more extended operations outside scare them in. The same weight is to be attached to the charge that the seines injure the shad fishery by capturing the fish. The total number of shad caught by all the members of the Oil and Guano Association combined does not amount to over two hundred barrels per year. Salmon are never caught in their seines."

I.—THE MENHADEN FISHERIES.

28.—The fishing grounds.

The location of the fishing grounds.

157. As has been already indicated in the description of the migrations and movements of the menhaden, there are certain portions of the coast which they frequent more certainly and constantly. These are marked upon the map accompanying this memoir and may be designated as (1) the Booth Bay Region, (2) the Cape Ann Region, (3) the Cape Cod Region, (4) the Narragansett Bay Region, (5) the Long Island Sound Region, (7) the Sandy Hook Region, (8) the Chesapeake Region, and (9) the Hatteras Region.*

Bearing in mind the fact that the menhaden is fond of shallow, brackish waters while the mackerel is not, it is quite curious to remark that their favorite haunts are much the same. Both species are caught most successfully in the great, partially-protected indentations of the coast. Whether it is on account of the calm waters, the abundance of food, or the detention of the schools in these great "pockets," as they may be called, is not apparent. Perhaps all have their influence, probably the latter has the greatest.

In these localities, at different seasons of the year, the fisheries can be most successfully carried on, and here only can they be made profitable.

29.—Methods of capture.

Past and present methods contrasted.

158. Twenty years, ago when the menhaden fisheries were of very small importance, the business of manufacturing oil and guano being still in its infancy the only use for the fish was as a fertilizer in its raw state. This demand was easily supplied by the use of seines and gill-nets along the shore, for at that time the habits of the fish were probably very different. They swarmed our bays and inlets, and there is quite good authority for the story that 1,300,000 were once taken with

* Plate XI.

one haul of the seine in New Haven Harbor.* Constant fishing on the northern coast has driven the menhaden out to sea, though in the south their habits are much the same as of old. In NewEngland the menhaden fishery has become to a considerable extent sea-fishing, and is prosecuted on the grandest scale.

Estimates of numbers of vessels and fishermen by collectors of customs.

159. Under the statistics of manufacture will be found the statements of the manufacturers in reference to the number of vessels and men employed by them. It may not be out of place here to give a corresponding estimate on the part of the collectors of customs and others in connection with a general statement of the location and methods of the fisheries. The manufacturers' enumeration excludes the vessels engaged in catching the menhaden for bait, but is, as far as it goes, probably more nearly correct than any other, the laws of registration being so lax that many fishing-vessels do not appear upon the custom-house books.

Fisheries of Maine.

160. Mr. William H. Sargent estimates for the district of Castine, Me., about 20 decked vessels and 150 open boats. The vessels range from 15 to 80 tons. The number of men employed (probably including the factory hands) is about 425.

For the district of Belfast, Mr. Marshall Davis estimated in 1873 about 25 vessels with 125 men. In 1877, according to the same authority, there were about 100 boats owned by line fishermen, each of which uses from three to six gill-nets.

Mr. Benjamin F. Brightman, collector of customs at Waldoborough, Me., gives 54 gangs of 10 to 12 men each. This district includes the region between the Penobscot and Kennebec Rivers, where all the large factories are located. The vessels in this region are steamers, schooners, and sloops of from 20 to 100 tons. This estimate is for 1873 and reference to the report of the Maine Menhaden Oil and Guano Association for the same year shows that these gangs include 55 vessels, 17 of which were steamers and 533 men. The number of men for 1874 is 551. More than half of these gangs are fitted out in Rhode Island.

For the town of Booth Bay, in this district, Mr. G. B. Kenniston estimates 21 gangs and 210 men.

Mr. J. Washburn, jr., collector of the Portland, Me., district, gives an aggregate of 110 vessels with 500 men, but this estimate evidently includes parts of other districts.

* Mr. Arthur T. Neale, of the Connecticut Agricultural Experiment Station, tells me that he has talked with one of the fishermen concerned in this famous haul. There was no accurate account of the numbers and the catch was variously estimated at from 1,000,000 to 1,300,000. Numerous carts were employed for three days in carrying the fish from the shore and finally a large part of the fish were allowed to escape.

Fisheries of Massachusetts.

161. Mr. F. T. Babson, of Gloucester, Mass., states that in his district are 40 vessels employing 400 men and a capital of $200,000. In this enumeration are included at least four steamers belonging to Judson Tarr & Co., of Rockport, which are used for their factory in Bristol, Me., and perhaps others. The remaining vessels are schooners of from 20 to 70 tons, which are wholly engaged in taking fish for bait. Fisheries of some importance are carried on at the mouth of the Merrimack River. They are described under the section relating to boats.

Mr. Simeon Dodge, of Marblehead, Mass., reports "no large vessels employed" in his district, though small boats fish for menhaden to be used for bait, and Mr. E. B. Phillips makes the same report for the vicinity of Swampscott.

Mr. Thomas Loring, Plymouth, Mass., says that in his district no vessels are wholly employed in this business; a few menhaden are caught for bait in gill-nets.

Capt. Hermann S. Dill, of Billingsgate Island, writes that for about three weeks, in the fall when menhaden are fat, 12 or 15 men and one or two small vessels are employed in catching them in Wellfleet Bay. A few are caught from dories.

About the extremity of Cape Cod very slight attention is paid to the menhaden. Capt. David F. Loring, keeper of Highland Light, North Lynn, Mass., writes under date February 23, 1875: "I believe the fishermen in this vicinity have an idea of going into the business quite extensively the coming season." He probably refers to the business ot catching the fish for bait, which would naturally prove very profitable in the neighborhood of a great fishing center like Provincetown.

At Chatham, on the heel of Cape Cod, according to Capt. Josiah Hardy, 2d, in Chatham Bay, there are 13 weirs, but no vessels are employed in taking the menhaden.

From Nantucket, Mass., Mr. Reuben C. Kenney, collector of customs, reports that sail-boats of 5 tons burden are employed in setting the gill-nets, of the proceeds of which about half is used for bait, the other half sent to factories upon the mainland.

In the vicinity of Hyannis, Mr. Alonzo F. Lothrop, keeper of the light, states there are no menhaden fisheries.

Edgartown, Mass., and the Island of Martha's Vineyard employ no vessels in this fishery. Mr. C. B. Marchant, collector, writes that large numbers are taken in the pounds, and are sold for bait.

Fisheries of Rhode Island.

162. In Narragansett Bay, according to Mr. Church, about 10 gangs and 100 men are employed. Nearly 30 gangs fit out for the fisheries in Maine, and these usually seine Narragansett Bay for a short time, spring and fall.

No vessels are engaged in the menhaden fisheries at New Shoreham, R. I. (Block Island), nor in the vicinity of Point Judith.

Fisheries of Connecticut.

163. In the vicinity of Fisher's Island Sound, according to Capt. William H. Potter, of Mystic, Conn., there are employed 14 large boats and 36 small, and about 240 fishermen. There are 14 gangs working between the Thames River and Stonington, Conn.

Between the Thames and the Connecticut, Capt. S. G. Beebe states that there are 8 sloops of about 20 tons, each carrying about 10 men. Luce Bros., of East Lynne, have 1 steamer, 9 sloops, 48 fishermen, and 40 factory hands.

Mr. R. E. Ingham, of Saybrook, Conn., thinks that between Saybrook and New Haven there are employed about 14 vessels and 80 men, but this estimate is undoubtedly too great.

In Western Connecticut, according to Mr. G. W. Miles, there are employed 7 gangs, with 21 sloops and 230 men. Mr. F. Lillingston, of Stratford, puts the figures at 30 sloops and 300 men.

Fisheries of New York.

164. For the Eastern District of Long Island, Mr. W. S. Havens estimates 60 vessels and 540 men. Captain Sisson, for 1873, put it at 105 vessels and 400 men; in this estimate he probably includes the lighter boats.

Hawkins Brothers, of Jamesport, N. Y., employ 110 men, 50 of whom are factory workmen.

The Sterling Company, of Greenport, N. Y., employ 3 gangs, consisting each of 8 men, 2 boys, and a cook, working from 3 yachts and 6 lighters.

Mr. Joseph D. Parsons, writing from Springs, Suffolk County, New York, December 10, 1877, states that in that vicinity 43 vessels and 175 men are employed in the menhaden fishery.

At the entrance to New York Bay and off Sandy Hook the fish are taken for the sardine factories, small sail-boats of about 10 tons being used.

Fisheries of New Jersey, Delaware, and Maryland.

165. In the vicinity of Little and Great Egg Harbor, New Jersey, Mr. A. G. Wolf, keeper of Absecum light-house, states that there are 10 vessels and 40 men employed; this includes the gill-net boats of 4 and 5 tons, sloops, schooners, and one steamer of about 15 tons. This perhaps includes the Somers Point Oil Works, where, according to Mr. Albert Morris, there is a gang of 9 men with 3 vessels.

In Delaware Bay there are no menhaden fisheries, though many of these fish are taken in seining for other kinds.

In Chesapeake Bay no effort is made to take them in quantity except

in Tangier and Pocomoke Sounds, where, according to Mr. Hance Lawson, of Crisfield, Md., there are employed 5 vessels averaging about 15 tons each and 5 oared barges. Small numbers are taken in gill and trap nets at other points.

Fisheries of Virginia and North Carolina.

166. In the inlets of North Carolina no menhaden are taken in quantity.

The Quinnipiac Fertilizer Company, of New Haven, inaugurated menhaden fishing in North Carolina and Virginia in 1866. Their prospecting party passed the winter in Roanoke Sound and established weirs for the capture of menhaden, which were there very abundant. They were, however, driven away by the natives, whose jealousy of strange fishermen led them to tear up their weirs. They then located themselves near Cape Charles. Four companies established factories here—one from Maine, one from Long Island, and two from New London. They found the fishery very good, although the fish produced little oil, and were only adapted for the manufacture of fertilizers. The laws of Virginia do not encourage the inauguration of such enterprises by strangers, and the following year it was thought unadvisable to continue the business.

Since 1872 several stock companies have been organized, under Virginia laws, for the purpose of carrying on the menhaden fisheries in the Chesapeake, and their success is well assured. Although the oil is not produced in great quantities, there is sufficient to pay the cost of manufacture, thus leaving a clear profit in the scraps.

Fisheries in the South.

167. At Cape Hatteras and in the five adjacent townships there are, according to Mr. Simpson, 200 boats and about 500 men. None of these, however, make a special effort to capture the menhaden.

In the rivers near Beaufort, N. C., they are taken in small quantities in gill-nets worked from open boats and canoes.

South of Beaufort, N. C., the menhaden has no statistical importance. They are sometimes caught incidentally in the shad and mullet nets of the Saint John's River, Florida, but, as in the Potomac, they are considered by the fishermen to be useless annoyances.

30.—Apparatus of capture.

The purse-seine.

168. The purse-seine is doubtless more effective than any other fishing apparatus ever devised. By its use a school of almost any size may be secured without the loss of a single fish. The enormous demands of the oil factories can be met only by fisheries conducted on the grandest scale, and the purse-seine is used by the factory fleets to the exclusion

of all other nets. In the vicinity of Gloucester, where menhaden are caught for bait, the purse-seine is also used. It need only be said that it is an immense net, which when in use is a flexible wall of twine, suspended by its upper edge, extending from 90 to 180 feet below the surface, and from 800 to 1,500 feet long. This wall is made to encircle the fish and then its lower edge is gathered up by a rope passing through rings prepared for the purpose. The seine when pursed becomes essentially a huge dip-net, from which the fish may be taken at the pleasure of their captors.

The purse-seine is said to have been invented about the year 1837 by a native of Maine, who had been for some years employed as a hand on a Gloucester fishing-smack. He conceived the idea of capturing mackerel in large numbers, and invented a seine which is substantially the same as that now in use. Finding the Gloucester fishermen unwilling to experiment with his new apparatus, he carried it to Rhode Island, where it was first put into use in the vicinity of Seaconnet for seining menhaden.

The first seine used north of Cape Cod was introduced in the year 1850 by Capt. Nathaniel Adams, of Gloucester, in the schooner "Splendid." Capt. Nathaniel Watson, of the "Raphael," began using one the same year.*

The early seines were about 200 yards in length, 22 fathoms in depth, and of 2.5 inch mesh, there being about 350 meshes in the bunt of the seine. The twine used was much heavier than that used in the present seines, and the whole net weighed six or seven hundred pounds. The present seine, however, did not come into general use, as I am informed by Mr. Marchant, of Gloucester, until about 1860.

During the last eight years there has been greater change in their size than during the ten years previous. In 1869 the nets were 160 fathoms in length, 700 meshes deep, the meshes being $2\frac{1}{4}$ inches, and would weigh about 400 pounds, being made of No. 9 twine (Hadley 29).

Fishing in deeper water began in the years from 1869 to 1872; and since that time a gradual increase has taken place in the size of the nets corresponding to that which has already been described in the case of the seine-boats. The popular size for seines in 1877 is 200 fathoms in length, 1,000 meshes deep, the mesh being 2 and $2\frac{1}{2}$ inches, those in the bunt being sometimes finer, the twine heavier. They are made of No. 6 twine (Hadley 16), and weigh about 700 pounds. The largest one known to Captain Marchant is 247 fathoms long, and weighs about 1,000 pounds.

In order to understand the method of working a purse-seine, it is necessary that the manner of "hanging it" should be described. At the top of the net is the cork-line, upon which corks are placed at distances apart of from 12 to 15 inches; two corks are usually put together (which are designated in trade as numbers 2 or 3), and are 4 inches in

* Mr. Maddocks states that the first purse-seine was used on Chelsea Beach.

diameter. There is no lead-line, properly speaking, though light weights are placed upon the bottom line of the seine, near the ends, about 2 ounces in weight, about 60 pounds in all, four inches apart at the sides, and farther apart near the middle. Sometimes twelve rings are strung close together so that they touch. The rings through which the pursing rope passes are almost heavy enough to render other weights unnecessary. The lower edge of the seine is hung on six-thread manilla rope; to this is attached a series of so-called bridles, these bridles being 3 fathoms in length and placed 3 fathoms apart. Upon each of these bridles slides an iron ring weighing $1\frac{1}{2}$ to $2\frac{1}{4}$ pounds and $3\frac{1}{4}$ inches in diameter; through these rings runs the purse-line. The average weight thus placed upon the bottom of the mackerel-seine is about 220 pounds; this, however, includes special leads put on at the ends of the seine, 55 to 80 pounds of lead being thus distributed in leads of one-eighth to one-quarter to one-sixth of a pound in weight. Upon the menhaden-seine about 35 pounds of lead is considered sufficient. In operating this seine a large heavy weight, called by the fishermen of Gloucester a purse-weight, by those of Southern New England "Long Tom," is used, which is placed upon the vertical ropes at the end of the seine by the use of snatch-blocks, and is allowed to run down to the bottom of these ropes, thus fastening securely together the ends of the so-called lead-line before the operation of pursing begins. The mackerel-seine is usually arranged so that when it is pursed there are large triangular flaps of netting hanging at the end and closing the opening. This is accomplished by allowing the purse-lines to pass obliquely from the last purse-rings, which are placed at the distance of about six feet from the ends of the lead-line. In mackerel-seining these are not, by all fishermen, considered necessary, as the mackerel do not, like the menhaden, strike for the bottom of the net when they find themselves inclosed. This weight weighs from 60 to 120 pounds, and varies somewhat in shape; the usual form is figured in plate XIV. Some seiners now use two smaller weights, one upon each line. The best fishermen prefer to use the weight, and by this method the largest fares of fish are taken.

The seines used by the menhaden vessels are smaller than mackerel seines, although the latter are frequently used in this fishery, especially near Gloucester.

From the letters of our correspondents it appears that the length of menhaden seines varies from 100 to 300 fathoms, and their depth from 10 to 25 fathoms. Some seines, 50 fathoms long and 5 fathoms deep, are mentioned, but these must have been exceptionally small.

In early days, it is said, a mesh of $4\frac{1}{4}$ inches was used. In 1873 Maine fishermen preferred a mesh of $3\frac{1}{4}$ inches. From 1875 to 1877 a still smaller mesh was employed. The seines now in use in Connecticut have a mesh of $2\frac{1}{2}$ inches (that is, $1\frac{1}{4}$ inches square, or $1\frac{1}{4}$ "bar"); they are 130 fathoms long when "hung," or 200 fathoms "straight twine" or stretched as they leave the factory, and 15 fathoms deep. They are made

of small cotton twine (No. 20 to No. 12 thread), except in the middle, or "bunt," which is knit of stronger twine (No. 14 to No. 9 thread), to hold the fish when they are gathered into a small compass. They weigh 600 or 700 pounds, and cost not far from $1,000 when ready for use. On the coast of Maine they are larger, being commonly from 225 to 275 fathoms long and 20 fathoms deep in the middle, tapering to 14 fathoms at each end.*

The American Net and Twine Company supplies the Maine fishermen with seines usually 250 fathoms long and 20 or 25 fathoms deep, those of Southern New England and New York with shorter ones, usually 150 fathoms long and 15 to 20 fathoms deep.

The steamers of the Pemaquid Oil Company carry each two seines; a long one and a short one. The long seines are about 9,500 meshes long and 650 meshes deep (size of mesh 3⅛ inches), and when rigged are from 280 to 300 fathoms long, and 15 to 17 fathoms deep. The shallow-water seines are from 7,000 to 7,500 meshes long and 500 to 550 meshes deep (size of mesh 2½ inches), and when rigged are from 170 to 180 fathoms long, and 8 to 10 fathoms deep. Each steamer employs from 12 to 15 men, including captain, mate, engineer, fireman, cook, and sharesmen, and is supplied with two large working boats from 22 to 82 feet long, as well as two small boats,—"drive boats,"—which are rowed by the men who drive the fish into the seine.

The three sloops of Gurdon S. Allyn & Co. carry seines 200 fathoms long and 580 meshes (2½-inch mesh) deep.

Gallup & Holmes use seines of 3-inch mesh, 9,200 meshes in length and 600 meshes deep, with shallower seines for shoal water.

The three steamers of E. T. De Blois carry seines 300 fathoms long and 17 fathoms deep.

The two sloop-yachts of William T. Fithian & Co., Napeague, N. Y., carry seines about 160 fathoms long and 15 fathoms deep.

The three sloop-yachts and two steamers of Hawkins Brothers, Jamesport, N. Y., carry seines from 100 to 130 fathoms in length and of 2½-inch mesh.

Luce Brothers, of East Lyme, Conn., use seines 150 fathoms long and 18 fathoms deep.

The seines used by the Sterling Company of Greenport, N. Y., are 125 to 150 fathoms long and 80 to 100 feet deep.

The seine-boats.

169. The boats used by the Gloucester fleet in the purse-seine fishery are built after a peculiar model and solely for this purpose. The present form of the seine-boat was devised, about the year 1857, by Messrs. Higgins & Gifford, boat-builders, Gloucester, Mass. The seines had previously been set from square-sterned lap-streak boats, about 28 feet in length, and resembling in shape an ordinary ship's yawl.

---

* Boardman and Atkins, *op. cit.*, p. 23.

The seine-boat as now in use resembles the well-known whale-boat, differing from it, however, in some important particulars.

The seine-boat, according to Mr. Gifford, must have three qualities: (1.) It should tow well; consequently it is made sharpest forward; a whale-boat, on the other hand, is sharpest aft, to facilitate backing after the whale has been struck. (2.) It should row well, and this quality also is obtained by the sharp bow; the whale-boat also should row well, but in this case it has been found desirable to sacrifice speed in part to the additional safety attained by having the stern sharper than the bow. (3.) It should be stiff or steady in the water, since the operation of shooting the seine necessitates much moving about in the boat.

The Gloucester seine-boat of the present day is a modification of the old-fashioned whale-boat, combining the qualities mentioned above. The average length of such a boat is about 34 feet, its width 7 feet 5 inches, its depth amidship 33 inches. At the stern is a platform, measing about 4 feet, fore and aft, on which the captain stands to steer: this is 6 to 8 inches below the gunwale. Another platform extends the whole length of the boat's bottom, from the after part of which the seine is set. In the bow is still another platform, on which stands the man who hauls the cork-line. There are four thwarts or seats, a large space being left clear behind the middle of the boat for the stowage of the seines. Upon the starboard side of the boat, near the middle, is arranged an upright iron support, about 18 inches in height, to which are attached two iron snatch-blocks used in the working of the purse ropes. Upon the opposite side of the boat, generally near the bow and stern, but with position varied according to the fancies of the fisherman, are fixed in the gunwale two staples, to which are attached other snatch-blocks used to secure additional purchase upon the purse-ropes. In the center of the platform at the stern of the boat is placed a large wooden pump, used to draw out the water which accumulates in large quantities during the hauling of the seine. The steering rowlocks, with the peculiar attachment for the tow rope and the metallic fixtures described above, are manufactured especially for seine-boats by Messrs. Wilcox & Crittenden, Middletown, Conn.*

Until 1872 the seine-boats were always built in the lap-streak style; since that time an improved form of smooth-bottomed boats, built with battened seam set-work, sheathed inside with pine, and with oak frame and pine platform, has been growing in popularity. The advantages claimed for this boat by the builders are: (1.) Increased speed; (2.) greater durability, on account of the more solid character of the wood-work and tighter seams; and, (3.) less liability to catch the twine of the nets by reason of the smooth sides. It is not so stiff as a lap-streaked boat of same width, but in other respects superior.

Since the general adoption of the purse-seine, in the menhaden and mackerel fisheries, an account of which is given elsewhere, there has

* The Cape Ann seine-boat, with all its attachments, is illustrated in Plate XV.

been a gradual increase from year to year in the size of the seine-boats, keeping pace with a corresponding increase in the size of the seines.

In 1857 all boats were 28 feet in length. In 1872 the length had increased to 30 feet, and in the summer and fall of the same year an additional foot was added to the length. In 1873 almost all boats which were built had a length of 31 feet; a few of 32 and 33. In 1874 almost all were 33 feet, as they were during 1875 and 1876, although some were made 35 and 36 feet. In 1877, 34 feet is the most popular length, though one or two 38-foot boats have been built. Seven, eight, or nine oars, usually 13 or 14 feet in length, are used in these boats, besides a steering-oar of 16 or 17 feet.

These boats last, with ordinary usage, six or seven years. At the close of the fishing season they are always taken ashore and laid up for the winter, in a shed or under trees, and are completely refitted at the beginning of another season.

The seine-boats, carried by the "menhaden catchers" south of Cape Cod and by all the steamers, are shaped like ships' yawls, square-sterned, smooth-bottomed, and batten-seamed, 22 to 26 feet long and 6½ feet beam; they are built at New Bedford, New London, Greenport, and at Mystic River, and cost about $125 each, the finest $185. The New Bedford boats are preferred by many fishermen.

When boats of this model are used every gang has two, each carrying three men and half of the seine; this arrangement leaves one of the crew upon the sloop and two in the lighter. On the coast of Maine, a man is usually sent out in a dory to drive the fish.

The Cape Ann fishermen stow their seines in one boat, and in shooting the seine one end of it is carried in a dory.

The Cape Ann dory is 15 feet long on the bottom, 19 on top, 5 feet 2 inches beam amidships, 21.5 inches deep, 36 inches high at the stem, 34 inches at the stern, 2 feet 10 inches wide at bottom of stern. These dories are built with considerable difference in their "sheer," those used on the shore having a straighter bottom than those used in the Bank fisheries. The boats used on the seine fisheries are generally of an intermediate form.

Messrs. Higgins & Gifford manufacture an improved pattern of dory (patented January 2, 1877), for which they claim the same advantages already mentioned under the description of the seine-boat. They are built of pine, with oak-timber gunwales, stem and stern. There are four boards upon each side fastened in battened set-work. The gunwales are whole instead of being bent and capped. They have no projecting stem-head, in this respect also differing from the old form.*

The sailing-vessels and steamers.

170. Small schooners and sloops were used in the early stage of the business, these succeeded by larger, and these to a great extent by

* The Cape Ann dory is illustrated in Plate XVI, fig. 1.

steamers, of which there are now about sixty, each from 60 to 150 feet in length, and costing from $7,000 to $40,000. The advantages of steam are too obvious to need special notice, such as dispatch, economy of time and labor, etc. With the advent of steam-vessels, larger factories with more ample equipment become a necessity in order to utilize the augmented supply. The first factory had the capacity to work up 500 barrels per day. The larger factories can now take 3,000 to 4,000 barrels daily. At the outset 4,000 barrels per steamer was a large catch to each fishing "gang." Now the average catch per steamer is 10,000 barrels, and 20,000 barrels are not unprecedented.* The Pemaquid Oil Company employs several vessels in shipping oil, and in carrying the dried scrap to England.†

Description of steamers.

171. The average burden of the menhaden-steamers is about 60 tons. They are built of hard pine, with white-oak frames, with a water-tight tank in the middle in which the fish are stowed. This tank is said to make the vessels exceedingly safe, enabling them to float when their planking is badly injured. The steamer "Jemima Boomer," owned by Joseph Church & Co., while at sea in rough weather had 50 feet of her keel knocked out, together with eleven of the bottom planks. She was taken upon a marine dock without sinking. Each steamer carries from twelve to fifteen men, who live in the forecastle.‡

Mr. George Devoll, of Fall River, Mass., describes his steamer, the "Chance Shot." It is 39 tons in burden, 68 feet long, and 18 feet wide, and 5 feet in depth of hold. Its carrying capacity is about 700 barrels of fish. The consumption of coal is about one ton daily. The cost of running is about $8 per day, including coal, oil, and the wages of the engineer. The crew are employed on shares, each man paying his own board and running his chance. The boat and seine draw one-half of the profits, and the gang half—the gang paying provision-bills and cook's wages. There are seven men in the gang besides the cook and the engineer.

A model of the fishing steamer "Leonard Brightman," owned by Joseph Church & Co., of Round Pond, Me., was exhibited in the United States Government building in Philadelphia and is now deposited in the National Museum. The steamer "Seven Brothers," also owned by Joseph Church & Co., was the first steamer built for and used in this fishery.

31.—Certain requirements of purse-seine fishing.

Methods of handling the net.

172. Much care and expedition are necessary in handling a purse-seine full of fish. In the event of a very large draught, if the fish are

* Maddock's Menhaden Fishery of Maine, p. 15.

† Appendix I, contains a partial list of vessels employed in the menhaden fishery.

‡ Plates XVII and XVIII show the menhaden-steamer and its plan of arrangement.

left in the net too long they are killed by the confinement and close pressure, and sink. In such a case the only alternative offered the fishermen is to cut open their seine. Sometimes the dead fish carry the net with them to the bottom. When there are more than enough fish in the seine to fill the vessel to which it belongs, and there is danger that they may be lost, other vessels which are near often take the surplus fish. In such a case, writes Mr. Babson, one-half the value of the fish is paid to the captors.

In calm or moderate weather, fishing is carried on from dawn till dark, though morning and evening seem most favorable. In rough weather the nets are not easily set, while the fish usually swim farther from the surface and cannot be seen. Cold northerly and easterly winds seem to affect the fish, causing them to sink toward the bottom. Southerly winds seem the most propitious.

Mr. Dudley states that in the fall, during the southward migration, the fish play at the surface with a northwest wind.

The best time for seining.

173. The early morning is apt to be the stillest part of the day, and a large part of the fish are taken at that time.

So far as I can learn, the motions of the fish are not particularly affected by the tides, except that, like other *Clupeidæ*, they prefer to swim *against* strong tides and winds. An impression seems to hold among the fishermen that rather better success attends fishing on the flood-tide. This is no doubt the case where gill-nets are in use, for in localities where the fish have not been frightened off shore by constant fishing they like to play up into coves and bays with the rising tide, and are then easily taken by the gill-nets and the pounds or weirs.

Where the purse-seines are worked in deep water off the shore, as on the coast of Maine, little attention need be paid to the tides; but where they are used in bays or channels where the tide has much head, there is a practical difficulty in using them except at or near the time of slack water. In a swift current the seine is liable to accidents from being caught on rocks or other obstructions, or may be capsized or pulled out of position. In Narragansett Bay, the difficulties of this kind appear to be particularly great. According to Mr. Church it is not uncommon for a gang to work all day without success, their net being capsized every time it is set.

32.—Descriptions of fishing scenes.

Menhaden fishing in Southern New England.

174. The first time the writer ever saw menhaden-fishing was in August, 1874, when cruising off Watch Hill, Rhode Island, in the Fish Commission yacht "Cygnet." Several trim-built sloops are beating off and on, within a mile of the rocks. That they are "bony-fish catchers"

is evident from the two long boats which are towed astern, carrying the purse-seine, which looks like a bale of brown hay stowed in the middle of each boat. A man stands at every mast-head watching for the well-known ripple. A school passes under the bows of our yacht and rises to the surface at a short distance, the bright sides of the fishes glistening in the sun and their tails flipping the surface noisily. The sharp eyes of the "lookout" of the nearest vessel soon detects their presence. The sloop comes about and sails to the leeward of the school. As soon as they are near, three men jump into each boat. Two man the oars, a third stands in the stern and pays out the net, while the boats, rapidly diverging, are rowed around the fish, each describing a semicircular course. Now their courses converge and the men row faster. They come together and pass, thus closing the circle of network. The men all jump into one boat, the purse-weight, or "long Tom," as they call it, is hooked to the two lead lines, and a splash of water announces that it has been thrown overboard to slide down the ropes and draw the lower ends of the net together. Now they begin hauling at the bottom lines, and in ten minutes they have drawn the bottom of the net into a purse and the fish are secured. The "lighter," or transporting boat, now sails up. The men on board heave a line to the seine-boats and they are brought alongside. A large dip-net, three feet in diameter, is now suspended by a block and tackle in the rigging of the lighter, and the fish are rapidly transferred from the seine to its hold. The silvery masses of fish are hoisted into the air and dropped into the vessel, settling in the bins with a flapping noise like the sound of distant thunder or the hand-clapping of a large audience.

In August, 1876, when on the steamer from Saybrook to Greenport, I saw a fleet of sixty vessels busily plying their nets in the sound near the mouth of the Connecticut. In the evening a gale sprang up from the southwest, and as the steamer entered Peconic Bay the little sloops were seen scudding to harbor under low-reefed sails. Every wave swept the decks, but they floated like sea-birds. Some of them were loaded to the rail with fares of fish.

Menhaden fishing about Cape Ann.

175. We are indebted to Captain Babson for facts about the fisheries at Cape Ann, which are carried on for the purpose of securing bait for the codfish and mackerel fleets. Vessels for this business are fitted out from the port of Gloucester on the same basis as those for other fisheries. The owners furnish the vessel-outfits, seine and boats, the crew going "on the halves"; that is, taking for their share half of the entire "catch" while the other half is claimed by the owners. A good vessel with boats costs about $5,000. A seine costs about $1,000, and with fair usage lasts through two seasons; it is made of cotton twine and preserved by the use of salt and tar. The seine is carried on a small deck at the stern of the seine-boat, which is about 30 feet long and 8 feet

wide and is built on the plan of a whale-boat of the old style. Only one seine-boat is used here, and on this the whole seine is carried, one end of the seine being taken by a "dory" with two oarsmen.

The Cape Ann Advertiser reported in 1872 that the menhaden fishery was prosecuted by about 40 vessels from that port.

Mr. Frederic G. Wonson, of Gloucester, states that the crew of a "pogie-catcher" consists of about 10 men, and that the cost of a three weeks' trip is about $400.

Menhaden fishing in Maine.

176. Mr. Church has furnished a very full account of the organization of crews on the seining-vessels. The largest steamers are 70 tons in burden, the smallest 25, the sailing-vessels about 30; these vessels are used for the men to live on, and tenders are employed to carry the fish to the factories. These tenders have an average capacity of 250 barrels, though recently they are built of a larger size, some carrying 600 barrels. Besides these there are the "purse" and "mate" boats from which the seine is worked. These are 28 feet long, 6 feet wide, and 2 deep. The sailing-vessel has a cook who manages the vessel while the crew are working the seine. Each boat carries a "seine-setter" and two men to row. The captain of the gang is in charge of the "purse-boat," the first mate of the other, and in addition to these most gangs have a "fish-driver," who keeps close to the school in a small-boat and guides the gang in setting the seine. Some gangs have still another man, called the "striker," who is generally an apprentice learning the business and working at low wages. Four men to row, two to set the seines, and one (the cook) to manage the vessel, seven in all, are all that are really necessary for steamer or sail-vessel, the other functionaries being added as may be convenient. "The seines are 280 fathoms long and 100 feet deep. One-half of the seine is put in each boat. The steamer cruises with men at mast-head looking for fish. When they raise a school they put what are called striker-boats on them. Each steamer has two, with one man in each; they are men with sharp eyes, quick and active. They row close to the school of fish, observe its course, and then by signs they direct the purse-crew how to set their seine to catch them. If fish get scared, they drive them with white sea-pebbles which they carry in their boats. If the fish turn to run out of the seine, they throw the pebbles before them, and as they pass through the water before them the fish turn and swim in an opposite direction. After the fish are surrounded the purse-crew and strikers all work together to get the seine around them. It is different from sail-gangs in this, that sail-gangs hoist the fish by hand, and have boats to take the fish from the fishing-grounds to market, while the purse-crew stay on the ground with a separate vessel. Steamers go on the ground, catch their fish, hoist them on board by steam, and when the day is done take them to market, and the same men that catch them discharge them." A steamer has no tenders, and thereby saves much

expense. A sail-vessel with a purse-gang of seven men requires three tenders, with a man to sail each of them, making ten men in all as sharesmen. The steamer dispenses with the three extra men, and in consideration of the expense of coal and machinery takes their three shares. This leaves the shares of the remaining men proportionally the same as on a sailing-vessel.

Sail-gangs and steamers have gear just alike to catch the fish. It is not a sure thing to catch even when they see plenty of fish. A gang last year set nineteen times and did not catch a fish.

A writer in the Boston Daily Advertiser newspaper of August 5, 1875, states that persons chartering a steamer and sharing equally the profits with its owner easily make from $1,000 to $3,000 in a season.

Boardman and Atkins thus describe the methods in use about Boothbay, Me., in 1874:

"Attached to each seine is a gang of fishermen and boats. The gangs are described as 'sailing gangs' or 'steamer gangs,' according to the means of locomotion. A sailing gang comprises two working boats and a light row-boat for the 'driver'; two carry-away boats, with a capacity of about 250 barrels each; one vessel and ten men in all. The working boats work the seine, the carry-away boats carry to the factory, and on the vessel the crew are fed and lodged. In a steamer gang, the vessel and the carry-away boats are replaced by a screw-steamer of 35 to 60 tons (new measurement), and the number of men is reduced to nine. These steamers cost from $10,000 to $16,000 each, and will carry 800 barrels of fish. They were introduced on the coast of Maine three years ago. The advantage of the steamer over the sailing gang is obvious. It is not dependent on the wind, and can proceed without loss of time to the place where the fish are playing. Of course they catch a great many more fish, but they are so much more expensive that they do not appear to be much more profitable. The seine gangs are always attached to the oil-factories, and the latter employ no other mode of fishing. Each factory runs several gangs.

"Let us now follow the process of catching the fish as practiced by a steamer gang. We will begin at the sailing of the gang from the harbor, some clear morning in August. The engineer bestirs himself and has on steam early enough to reach the fishing-ground about as early as the fish can be seen. The fishing-ground is just where experience, and particularly the experience of the last few days, dictates. Commonly it is out to sea. As soon as it is light a sharp watch is kept on every side. Wherever menhaden are seen, thither the steamer's head is pointed. Sometimes it is close by home, and sometimes twenty or thirty miles are passed over before there is a single school to be seen. On approaching a playing school they always try to get on the outside of it, because the first movement of a school of pogies on finding themselves entrapped is invariably a rush seaward. The driver, in his swift row-boat, armed with a pile of stones, gets on the other side. Having

divided the seine between them, one end and half the seine being on each, the two working boats approach the school within a short distance and endeavor to get in a favorable position. Sometimes a whole day will be spent in vain endeavors to get near swiftly moving or capricious schools. When the favorable moment comes the boats separate and row around the schools of fish, paying out the seine from each as they go. Meanwhile the driver, on the opposite side, throws stones at the timid fish and starts them in the direction of the boats. At last the boats have encircled the fish, and meet on the side opposite to their starting point; instantly the purse-lines are seized, and no man stops to breathe until the bottom is pursed up. The crews exert themselves to complete the operation before the fish take the alarm, and many a time it happens that they pass out between the boats just before they meet, or under the bottom of the seine before the pursing is complete. The affrighted fish first, it is said, rush seaward. Finding themselves shut in on that side, they turn and rush landward; headed off there, they furiously follow the net around at the top of the water, some going this way and some that. Finding the circuit complete, they gradually subside, and finally settle to the bottom of the bag. The seine is now drawn aboard the working boats until only a small portion of it is left in the water, and the fish brought in a compact body to the surface. The steamer is now brought alongside, and with a great tub holding two or three barrels, and worked by steam, the fish are rapidly taken on board. When everything works well it takes about two hours to catch and take on board a school of 500 barrels; commonly it is longer than that." *

Gill-net fishing in Eastern Maine.

177. East of the Penobscot River, in Maine, most of the fishing is carried on with "float" or gill nets. These are knit usually of twine (size No. 12 to 14, 4-threaded), and of 3½ to 4 inch mesh, and are from 30 to 180 feet in length and from 6 to 16 and 24 feet in depth; usually from 12 to 18. Two men in an open sail-boat will, according to Mr. W. H. Sargent, of Castine, take care of a dozen nets. These nets are usually set in the night by being anchored in favorite haunts of the menhaden. When a school strikes the net large numbers of the fish are "meshed" by running their heads through the openings until they are caught by the gill-covers. According to Mr. Brightman, of Waldoborough, the gill-netting in that vicinity is mostly done early in the season; he states that this method of fishing is not nearly so productive as in former years. Netters sometimes build a furnace for trying out oil on the deck of a small vessel, thus saving the trouble of transportation.

Gill-nets are also used about Boothbay in the early part of the season, but not so much as formerly. The nets are made, according to Mr. Brightman, of fine cotton twine, about 4 inches mesh, 12 feet deep, and 20 fathoms long.

---

* Op. cit., pp. 24, 25.

Until the introduction of the purse-seine and its general adoption, about the year 1860, gill-nets were exclusively used. In the intermediate time the stationary gill-nets were supplanted by sweep-nets, arranged by fastening together several small gill-nets.

Weir fishing for menhaden.

178. Weirs and pounds are never set for the express purpose of capturing the menhaden, but large numbers of these fish are taken in these traps. In Chatham Bay, Massachusetts, there are thirteen weirs of various lengths set in water from 2 to 5 fathoms in depth for the purpose of catching mackerel, sea-bass, and shad. The average catch of menhaden for the past five years has been about 5,000 barrels, about half of which is sold for bait, the remainder thrown away. Goodale and Atkins state that on the coast of Maine there are a very few weirs built especially for the capture of menhaden; two or three near Stockton, on Penobscot Bay, being all of which they have knowledge. Some are also taken in the weirs built for salmon and alewives. The herring-weirs, on the other hand, are not adapted to their capture, their entrances being so wide that the menhaden generally "play out" after once entering.

On the eastern end of Martha's Vineyard are numerous pounds, extending 1,200 feet and more from the shore, set for sea-bass, squeteague, scuppaug, and bonitos. Many menhaden are taken here, which are sold for bait.

In the vicinity of Greenport, N. Y., "'longshore seines" are sometimes used, though not so generally as in former years, when this was the usual mode of capture.

Colonel Lyman on weir fishing at Waquoit.

179. Col. Theodore Lyman has given a very graphic account of the capture of bait menhaden in the Vineyard Sound:

"The weir is hauled once a day, and always at slack water, because with a strong tide running east or west it is impossible to handle the bottom-lines. The men pull out in two parties, of which one in a large scow passes round the outside of the bowl, casting off the bottom-lines, while the other in a yawl-boat pushes inside the bowl, pulls up the sliding poles, and closes the entrances. The slackening of the bottom-lines allows the bowl-net to hang free, and the crew inside begin to haul up the bottom of this net in such a way as to work the fish toward one corner, letting the net as it comes to the surface pass under their boat, which is thus slowly drawn across the bowl toward the corner where the capture is to take place, and where the scow is already waiting outside.

"The scene now becomes an exciting one. The menhaden in thousands begin to show the sharp upper lobes of their tails above the water;

here and there darts a feverish mackerel like a blue and silver flash; great leathery skates, looking like pigs rolled out flat, raise their snouts in slow astonishment; here a shark suddenly works his way through the crowding mob; hundreds of goggle-eyed squid, smothered in the press, feebly ply their force-pumps; and there the murderous bluefish, undismayed by imminent death, glares fiercely and snaps his savage jaw to the last. All these, with flat-fish, sea-robins, butter-fish, and many more, are taken and rolled in a fluttering mass iridescent with changing colors, and shower their silver scales high in air. It moves even the wear-men, in their oil-skin clothes, with a slight excitement as they cull out from the menhaden the choice and the offal fishes. There is Uncle Abishai smiting sharks with a spear, like so many Sauls, and he smiteth them not twice, and Captain Ed'ard endeavoring with a swift scoop-net to capture a dodging shad, because Mrs. Asa has boarders and needs a fish for dinner; and Captain Charles, with the air of one who gets a toy for a good child, diligently striving after some of them 'ere striped robins that the professor wanted. All this is strange and entertaining even to a commissioner, who, by the motion of a long swell and the evil piscatory odor, is somewhat afflicted with what the local satire terms 'white-ears.' And now the menhaden, bushels on bushels, are scooped all quivering into the great scow, for a little outside lies a mackereler who has just let go her anchor with a rattle, and a boat is pulling in with the skipper to buy bait. 'What you got,' cries he, in an indifferent tone. 'Menhaden,' retorts Captain Warren, as if speaking of a new and scarce fish. (A pause.) 'I don't know but I might take a few barrels if they was low,' says the skipper. (No reply.) 'What do you want for 'em?' 'Eighty-five cents,' shouts Captain Warren, and then (*sotto voce*), 'I don't believe he's got a scale.' At this answer, the man of mackerel pushes over the tiller and steers off indignantly; but presently pauses, 'Give you sixty-five, for seventy barrels.' 'Seventy-five cents is the lowest,' replies Captain Warren. 'Call it seventy cents for seventy-five barrels.' 'Waal! Waal!' And by this time the scow is full, and the weir-men pull for the vessel, whose numerous crew is ready to hoist the bait on board and salt it down. They stand with knives, barrels, and chopping-blocks, and rapidly cut off the heads and tails of the fish, and the thin parts of the sides, then give a gash in the shoulder, and throw them into the barrel for salting. A mackereler will take as many as 120 barrels of such bait, which is minced fine in a hand-mill and thrown over to toll the fish.

"Many years ago, when mackerel were cheap, the younger ones, called 'No. 3s,' were laboriously chopped up with a hatchet and thrown over as 'chum.' When mackerel became dear, especially during the war, the No. 3s were too valuable to be thrown away, and cheaper material, such as menhaden, was resorted to."*

*Ann. Rep. Commissioners on Inland Fisheries, for the year ending January 1, 1872, pp. 24, 25.

Fatback fishing in North Carolina.

180. At Cape Hatteras, according to Mr. A. W. Simpson, two kinds of nets are used in the capture of the "fatback." The "drag-net" is from 75 to 100 yards long, and 25 to 37 meshes deep, with a mesh of from 1½ to 2 inches. The lead line is provided with heavy lead sinkers, the cork line with floats made of gum-tree roots. The "set net" (which like the preceding is made of gill-twine No. 25 or 30, and five or six strand cotton cord made of No. 10 cotton) is from 35 to 45 yards in length, 18 to 20 meshes deep, the mesh being the same as in the "drag-net." Instead of a lead line is used a heavy cotton cord which has been dipped in pine tar and rolled in a bed of pebbly sand until a sufficient quantity is fastened to it to weight the bottom of the net. Such a net is called a "fly-tale," and is set at night on the playing ground of the fish, with both ends made fast. To work these nets canoes are used, ranging from 16 to 30 feet in length and 3½ to 7 in beam; two men are required for a small canoe, three for a large one. The fish are taken mostly on the flood-tide. When fishing with the drag-net, moderate weather is preferred; with the gill-net, a light wind, as the fish run most in windy weather. The fishermen do not make a special business of catching the menhaden, but are on the lookout for all kinds of fish. Purse-nets have been used about Cape Hatteras, but without very great results.

In the rivers near Beaufort, N. C., according to Mr. Davis, the fatbacks are taken in gill-nets about 50 fathoms in length, and 50 or 60 meshes deep, the meshes being 1¼ to 1⅝ inch in dimension. Nets which are partially worn out are generally used, the fishermen having an idea that the slime of the fatback ruins a net so that it cannot be used after the first season. The nets are worked from open boats and canoes carrying from 10 to 25 barrels of fish. Two men and a boat are necessary for each net. In making what is called a "drop," from four to six boats join their nets and surround the school. The fish, getting confused, mesh themselves and are easily pulled in with the net, and are then disentangled. From two to four hours are necessary for each haul, and one haul will generally fill the canoes. Two loads can be taken in a day.

33.—THE RELATION OF THE MENHADEN FISHERY TO THE FISHERMEN AND THE MARITIME VILLAGES.

181. On the coast of Maine, according to Mr. Maddocks, "the catching of menhaden is a favorite occupation with fishermen. The steamers return every night if they have any fare, and are hardly ever absent more than two or three days. Operations are suspended in bad weather. The oil is manufactured at once, and meets a ready market. The men can thus be promptly paid; whereas in the mackerel and cod fisheries the hands are obliged to wait until the end of the season for settlement, the service is dangerous, and comparatively full of hardships, the Men-

haden Association has never lost a man in its service, and not one of the steamers has ever burst a boiler. This is the more important since the cod and mackerel fisheries have been and are grievously oppressed, and greatly reduced by the tariff regulation that admits English fish free to our markets. The Englishman can build his craft at less cost than the American, can fit and equip her cheaper, and can therefore afford to sell his fish at a lower figure than the home fisherman; and at the same time he pays none of our taxes while enjoying the benefit of our market. The menhaden fishery has afforded no little relief in this condition of things to the unemployed fishing population on our coast and elsewhere."

182. Mr. Maddocks gives a very interesting picture of the influence of the menhaden fishery upon the population of the neighboring shores.

In the villages of Boothbay, Bristol, Bremen, and East Boothbay, the centers of the menhaden fishery on the Maine coast, the number of dwellings has doubled in the past few years, and all the outward signs of thrift, of enlarged comfort and abundance manifest themselves. The companies engaged in the menhaden business pay in the aggregate a handsome per cent. of the annual taxes of the towns in which they are located. The oil companies of Bremen pay over one-fourth of the total tax of the municipality. The oil-factories of Boothbay have, since they were built, paid an amount of tax equal to two-thirds of the war debt of the town. The Bristol factories pay one-eighth of the town tax. The indirect contributions of the business to the public treasury, by promoting the building of houses, vessels, &c., have been very considerable. All the money made has been spent on the spot, where it is open to taxation.

"About $60,000 worth of cotton twine is used yearly in the menhaden fishery of Maine for the manufacture and repair of seines. Quite a number of hands, men, boys, and girls, are employed in this work. The seines are of course made by machinery. Ten thousand tons of coal are consumed for various purposes, and 40,000 bushels of salt."

A correspondent of the "American Agriculturist" states in that paper* that the proceeds of the menhaden fishery and industry between New London and Stonington in 1872 amounted to $113,000, which was distributed along the coast of 12 miles on the north side of Fisher's Island sound. The business gave employment to over 200 men at the factories, and indirectly to as many more, besides the business of freighting the products.

34.—Protective legislation.

Laws of Maine.

183. The legislative acts relating to the menhaden fishery in Maine are summed up as follows:

Sec. I, chap. 313, Public Laws, 1865, provides as follows:

"No person shall set or use any seine within three miles of the shore

*American Agriculturist, 1873, vol. XXXII, p. 139.

in any waters of this State, for the purpose of taking menhaden or pogies; but a net of no more than one hundred and thirty meshes deep shall not be deemed a seine." * * * * * *

The penalty for violation of this act was fixed at "not less than four hundred nor more than one thousand dollars, and the forfeiture of all the vessels and apparatus employed."

By the act of February 21, 1866, chap. 30, Public Laws, the penalty for violation of the law was reduced to "not less than one hundred nor more than five hundred dollars," and the number of meshes deep increased to one hundred and forty to constitute a seine.

The act of February 27, 1869, chap. 36, Public Laws, repeals the foregoing, and re-enacts it in substance with various modifications.

The legislature of 1870 re-enacted the above with fuller details as to the collection of penalties, &c. Chap. 120, Public Laws, 1870.

In the revision of the statutes in 1871 the above act was consolidated into one section, sec. 54, chap. 40, Revised Statutes, 1871, which still retained the three-mile restriction, and the penalty of one hundred to five hundred dollars for each violation, and a forfeiture of all equipment employed.

Chap. 211, Public Laws, 1871, approved February 27, 1871, repeals the above sec. 54, chap. 40, of the Revised Statutes.

Laws of Massachusetts.

184. The following acts have been passed by the legislature of Massachusetts:

"AN ACT to protect the menhaden fishery in the towns of Duxbury, Plymouth, and Kingston.

"(Ch. 85.) SECTION 1. *Be it enacted*, Every person who shall, between the first day of May and the first day of November, inclusive, in each year, deposit the offal or waste dressing of the menhaden fish upon the shores or flats, or throw the same into the waters of the bays, harbors, rivers, or creeks of the towns of Duxbury, Plymouth, or Kingston, shall, for each and every offense, forfeit and pay a sum not exceeding fifty dollars, one-half to the complainant, and the remainder to the town within whose jurisdiction the offense was committed, to be sued for and recovered in any court competent to try the same, on complaint of any one of the selectmen, or any legal voter of either of the towns of Duxbury, Kingston, or Plymouth.

"SEC. 2. Any boat, craft, vessel, or fishing apparatus used by persons violating the provisions of this act, may be seized and detained not exceeding forty-eight hours by the selectmen of either of the towns aforesaid, in order that the same, if need be, may be attached or arrested by due process of law, to satisfy said fine with costs.

"SEC. 3. This act shall take effect from and after its passage."—April 24, 1857.

"AN ACT regulating the seining of menhaden in the rivers of the commonwealth.

"(Ch. 52.) SECTION 1. *Be it enacted*, The mayor and aldermen of any city or the selectmen of any town situated upon or adjacent to any river in which the seining of the fish is now or may hereafter by law be prohibited, may, upon the petition of twelve or more legal voters, and after due notice and hearing thereon, grant permission to such persons, upon such condition and with such restrictions as they may see fit, to seine menhaden therein, if, in their judgment, the same is consistent with the public good: *Provided, however*, That in all cases where two or more cities or towns are situated upon such waters and interested in said fishery, no action shall be had except upon petition to each of them, and by their concurrent vote.

"SEC. 2. If any person so licensed shall exceed in any manner the terms of said permission, or violate any of the conditions thereof, he shall be subject to the same penalties as would attach to seining without such license.

"SEC. 3. Such license may be altered or revoked at any time, by the concurrent action of the municipal authorities granting the same."—[March 15, 1858.

"AN ACT relating to the taking of menhaden in the waters of Buzzard's Bay and Vineyard Sound.

[1856, ch. 176. Additional act, 1870, ch. 249.]

"(Ch. 212.) SECTION 1. *Be it enacted*, From and after the passage of this act it shall be lawful for any person to take menhaden by the use of the purse-seine, so called, in the waters of Buzzard's Bay or of Vineyard Sound, or the waters of any bays, inlets, or rivers bordering on or flowing into the same: *Provided*, That no authority shall be hereby given to use any such seine at the mouth of any river where there now is or where there may hereafter be a herring fishery established by law, until after the fifteenth day of June, in each year: *And provided further*, That no authority shall be hereby given to use any seine in the waters around Nantucket or the islands belonging thereto."—[May 9, 1865.

In the report of the commissioners of inland fisheries for 1877, p. 65, it is stated:

"Fishing with seines in the Merrimac, at the season when the menhaden stand in, is forbidden by law. The *mouth* of the river has, however, never been defined by the governor, as permitted by statute; and it was represented to the commissioners that valuable menhaden fisheries existed in this neutral ground of brackish water. Therefore, under the personal promise of the fishermen to capture no shad or salmon, and with the guarantee of responsible persons in Newburyport, the commissioners agreed to defer the definition of the river-mouth, and to assume that these menhaden were not positively included in the river proper."

K.—ECONOMICAL VALUE AND APPLICATION.

35.—THE MENHADEN AS A TABLE-FISH.

Its use in a fresh state.

185. In many parts of the United States menhaden are in favor as table-fishes. When perfectly fresh they are superior in flavor to most of the common shore-fishes, but if kept they soon acquire a rancid and oily flavor. The Maine fisherman finds his breakfast of fried pogies both substantial and palatable. I can testify from personal experience that a bony-fish chowder is not to be despised.

They are often eaten in the vicinity of Newburyport, under the name of "hard-head shad." They are considered more palatable than the early runs of the river shad.

I am indebted to Mr. Barnet Phillips, of the New York "Times," for the information that in 1813, during a season of scarcity, large numbers of moss-bunkers, both fresh and smoked, were consumed in New York City. It does not appear probable that they were ever extensively used for food except in seasons of scarcity.

Professor Gill, writing in 1856 of the fishes of New York, remarks that moss-bunkers appear in the markets in the fall months, but in small quantities.

Storer remarks* that the fishermen who supply Boston market with codfish set their nets about the outer islands in the harbor each night as they come up to the city, and examine them in the morning as they go out for the day's fishing. Large numbers of menhaden are thus taken, frequently one hundred barrels at a haul, and such as are not used for bait are sold to the poorer classes for food, at about 6¼ cents per dozen.

The Rev. A. W. Church, editor of the Middletown (Conn.) "Constitution," informs me that the moss-bunker is a staple article of food among the people living on the sea-coast of New Jersey in the vicinity of Bricksburg, Somers Point, etc., and ten or fifteen miles inland. Every family makes a practice of salting down a barrel or two for winter use. They are preferred to any other fish which can be taken in that vicinity.

In the fall and winter the alewife is in good demand on the shores of Chesapeake Bay. In November and early part of December, 1874, I frequently saw twenty or thirty strings on the tables in the Washington fish market and they seemed to meet with a ready sale at 40 cents a string, a price nearly as high as that of striped bass, the favorite fish in Washington.

At Cape Hatteras the winter fish are in demand and are salted in quantity for summer use. In 1873 they sold for $7 a barrel. The summer fish are used only as fertilizers.

---

* Hist. Fish. Mass., p. 159.

The abundance of bones and the oily flavor have given rise to a prejudice against the menhaden as a food-fish, which the oil factories on the coast have done much to confirm. Still the fish is not unpalatable, and is capable of much valuable service in the capacity of a table-fish.

Its use salted.

186. For many years salted menhaden have been shipped from Gloucester to the WestIndies and Guiana, to serve as food for the negroes upon the plantations. These fish are not carefully prepared, but are chiefly the surplusage of the bait supply remaining in the hands of outfitters of fishing vessels at the close of the season. They sell for about $2 per barrel. Mr. F. W. Homans ships from 1,500 to 2,000 barrels annually to Surinam. These would weigh from 300,000 to 400,000 pounds, and be worth in the aggregate some three or four thousand dollars. Other individuals doubtless dispose of their refuse stock in the same manner.

Capt. Moses Pettingell, of Newburyport, informs me that about the year 1840, and before, large quantities were annually salted down in Newburyport, to supply a regular market in the West Indies. Salted menhaden were found to meet with a readier sale than salted mackerel, since, while little inferior in quality, when well prepared, they could be sold at a much lower price.

In the "Topography and History of Wareham," 1815, it is stated that the inhabitants of Wareham and Plymouth were accustomed to vote to allow a certain number of barrels of alewives to be taken annually from the brooks within town limits, and that "menhaden were also taken in quantity at Wareham and barreled for exportation in former years." *

It is stated by the editor of Forest and Stream † that some Brooklyn people have a patented process for extracting the bones and superfluous oil from the menhaden or moss-bunkers, hitherto useless as food, and then salting the fish, which they claim are fully equal to No. 3 mackerel. Thus all parts are utilized.

Salt mackerel at times replaced by menhaden.

187. The inspection returns of Massachusetts show a curious relation between the annual returns of salted menhaden, alewives, shad, and mackerel. An examination of the table given in Appendix G shows that an effort was made during the season of scarcity in the mackerel fisheries to supply the demand by the use of menhaden.

The question of drawback on salt.

188. Capt. Fitz J. Babson, collector of customs for the port of Gloucester, states that the question yearly comes up as to whether the menhaden fishermen are entitled to privileges under the law granting

* Collections | of the | Massachusetts | Historical Society | —— | vol. iv. | of the second series. | Boston: | printed MDCCCXVI | : p. 284.

† Vol. II, 1874, p. 215.

drawback on salt used in pickling, nets, and fish. This discussion brings on the question whether menhaden are or are not "food-fishes." The decision has usually been made that they are food-fishes.

36.—FOOD PREPARATIONS DERIVED FROM MENHADEN.

The manufacture of sardines.

189. On the coast of New Jersey, near Port Monmouth, are several factories, which carry on an extensive business in canning menhaden in oil and spices. One of the largest of these is that of the American Sardine Company, a representation of which is given in Plate XXIV. Mr. F. F. Beals, of New York, gives the following description of the methods in use in this establishment:

"We aim to have our catch of moss-bunkers in by 6 or 7 o'clock a. m., as the fish seem to be strongly impregnated with phosphorus and soon spoil in warm weather. As soon as the fish are landed, we put our entire force of men to cleaning, cutting, and scaling, for which we have machines adapted. When the fish are cleaned, they are at once put in hogsheads, and salted just sufficiently to keep and to remove their extreme freshness. They are then packed in cooking cans, which are a little larger than the packing cans, and put into the tanks, where they are steamed for the space of about two hours. After the fish are taken out, they are placed in the regular market cans, which are then laid upon zinc-covered tables, where they are filled with salad oil. They then go to the tinners, who solder on the lids, after which the can is again steamed and vented, and passed up into the cleaning and labeling room. Each day's work is piled up separately, each can being thoroughly tested to see that it is perfectly air-tight. For this we have an experienced hand. Not a can is packed until it has stood for at least a month. At the expiration of this time, after being again tested, the cans are packed in wooden cases containing two dozen each, and are then ready for the market. As we make all our tin cases, we are able to secure good results, and it is a rare occurrence to have a swollen can. If there is one, it is at once thrown aside.

"Our company was incorporated April 21, 1871, under the laws of the State of New York. Seeing the magnitude of the sardine business on the other side of the Atlantic, we were impressed with the idea that there was a large field for operations in this country alone. We at once set about to find a fish which would supply the place of the European sardine. After many experiments, we at last found one to suit the purpose, viz, the moss-bunker, and commenced a series of experiments to find a means of extracting or softening the bones without the use of acids of any kind. After over a year of experiment, we at last found the desired process, which we secured under United States letters patent, dated May 21, 1872. This process consists of varous modes of steaming until the bones become so soft that they can be eaten, like the flesh of the fish, without the slightest inconvenience. The two first years most of our time was con-

sumed in experimenting, so that it was not until a year ago that we really commenced to manufacture, though prior to that we put up some goods. Last year, 1873, we packed and sold about 30,000 dozen whole cans or boxes. We have now capacity to turn out double that amount and we expect to be obliged to do so, as our trade is rapidly increasing. Our goods have received various awards, including a medal of merit at Vienna in 1873, and a silver medal at Bremen in 1874."

During the season of 1877, the works of the American Sardine Company were not in operation. Mr. Beals, the secretary, informs me that the manufacture will be pressed strongly in 1878.

The qualities of American sardines.

190. Many persons are incredulous with regard to the possibility of manufacturing sardines of good quality from the menhaden. It need only be said that they have been carefully tested by many unprejudiced judges in the city of Washington, and that the verdict has always been that they were almost equal to French sardines of the best brands. There can be no reasonable doubt that if olive oil of good quality were to be substituted for the cotton-seed oil now used in the preparation of American sardines, they would be fully equal to similar articles imported from abroad.

The American sardines should be carefully distinguished from the sardines prepared at Eastport, Me., from young herrings; they are sealed up in tin cases imported ready-made from France, and are put upon the market in the guise of foreign goods—a misrepresentation which is not at all necessary, since they are quite as good as the articles with which they profess to be identical.

Menhaden preserved in spices.

191. There are other establishments near Port Monmouth which prepare menhaden in spices and vinegar under the trade names of "Shadine," "Ocean Trout," and "American Club-fish." I have been unable to obtain statistics of this branch of manufacture. Hoope & Coit, of New York, contributed samples of these preparations to the Centennial collection of the United States Fish Commission, and I suppose this firm to be engaged in the manufacture.

"Russian sardines" are prepared at Eastport, Me., from the herring, and are branded with spurious names and labels imported from Germany.

Mr. Barnet Phillips describes, in the New York Times, a visit to the "ocean-trout" manufactory at Port Monmouth. He writes: "If the name of the *salmonidæ* be taken a little in vain, the trout manufactured out of moss-bunkers are by no means to be despised. "Ocean trout" may not be the *garum* cooked with Tragasœan salt, but is a fair fish-food and as an alimentary substance is in good demand. The process of manufacture is simple. The fresh fish are scaled by machinery, by means of a revolving wheel, are then cooked in steam, packed into

boxes, which boxes have a cover put on them perforated with a couple of holes. The box containing only the fish is then plunged into a bath of pickle, where it remains until it fills itself, then the box, now full of fish and pickle, goes through a second cooking. When all hot, filled with steam, the two minute holes are closed with solder, a label is put on, and the moss-bunker, now metamorphosed into "ocean trout," instead of being turned into oil or being employed as a top-dressing for sterile soil, makes quite a delectable food, and doubtless to-day the advance of civilization in the United States is shown in remote portions of the country by cairns made up entirely of empty tin boxes once filled with edible moss-bunker.

Goodale's "Extract of fish."

192. The Hon. S. L. Goodale, of Saco, Me. (secretary of the Maine Board of Agriculture from 1856–1873), has invented a process by which the juices of the flesh of fish are extracted to form an article of food which promises to be of much commercial value. He writes: "Some time since the idea was conceived by me and reduced to practice of concentrating the juices of the flesh of fish into a food extract. The attempts were successful and the product satisfactory, bearing close resemblance to Liebig's *extractum carnis*, and possessing a like percentage of saline constituents and extractive matter, soluble in alcohol. My results thus far indicate that the more abundantly occurring *Clupeidæ* appear to be much better adapted to this use than any other fish yet tested, especially the menhaden and the herring, the latter having a more distinctively fish flavor, the former more nearly a simply rich-cooked meat flavor. The alewife I have not yet proved, but anticipate excellent results from its employment.

"During the two seasons past I have worked a few barrels of menhaden at a time, at intervals of a fortnight or more, to see if the juices varied in flavor or richness. My apparatus is imperfect, and although the extract *must be*, judging from my former experience with beef extract, inferior in flavor to what it would be if prepared with a vacuum pan and all suitable conveniences, it is good enough to elicit many commendations. No one needs less than yourself to be told how great are the possibilities for this new project. From each barrel of menhaden, as taken, I get three pounds of extract when flesh alone is used and four pounds if the spine is retained in dressing. And my rejections yield just as much oil and scrap as any manufacturers get who treat them for this alone. The skins may be used to make glue. I remove them by scalding quickly, in either mode of dressing. The details of manufacture are fully worked out.

Considering the large amount of fish annually taken and hitherto treated for oil and scrap alone, the juices of which have been allowed to run back into the ocean as a worthless by-product, I cannot avoid the

conclusion that a new source of food is within reach, which at no distant day may contribute materially to human welfare."

Mr. Goodale exhibited specimens of the extract of fish at the International Exhibition in Philadelphia.

The writer has had an opportunity of testing the qualities of the preparation and can testify to its agreeable flavor and manifestly nutritive properties. Two tablespoonfuls of the jelly dissolved in hot water yield a large dish of savory soup, most closely resembling the *potage consommé* of the French cooks.

Professor S. W. Johnson, of Yale College, wrote to Mr. Goodale: "I cannot doubt that the fish extract is entirely new, and as food or stimulant is equal to beef extract in all respects (except *possibly* in the matter of iron*), and if put into the market in the proper shape would shortly share the patronage now so largely bestowed on beef extract, &c." And again: "I find your extract of fish both by actual use and by chemical analysis in all respects equal to the best Liebig's extract of beef.

Mr. Frederick Law Olmstead, of New York, wrote: "I have made a trial of your extract and find it more palatable than any beef extract I have used. It is not at all fishy, but I think it has a slight distinctive agreeable flavor which is also found in rich fish gravy. I am strongly disposed to regard it as a very important invention."

The extract of fish has also been tested in hospitals in Portland, Me., and in New York City. Concerning the latter, Professor Johnson may again be quoted: "The fish extract was tried in this hospital. The physicians consider it in no way inferior to Liebig's. It was not suspected by nurses or patients to be anything else."

Possible yield of "extract of fish."

193. Mr. Goodale estimates that the fish used by the factories in the towns of Bristol and Boothbay, Me., in 1873, 1874, and 1875, allowing the product to equal one-fifth of the weight of the live fish, would have yielded in either year upwards of a million of pounds, or five hundred tons of extract of fish. Carrying out the same calculation for the entire catch of the Atlantic States the potential yield of the menhaden fisheries would exceed ten millions of pounds.

37.—MENHADEN AS FOOD FOR ANIMALS.

Menhaden scrap as food for cattle and poultry.

194. At a meeting of the "Maine Board of Agriculture and Farmer's Convention" at Wiscasset, Mr. Wasson gave an interesting account

* With regard to Professor Johnson's suggestion of possible difference in contents of iron, I cannot speak confidently, but my impression is that this element occurs mainly if not wholly in the blood corpuscles; that these are entangled in the albuminous constituent, as it coagulates in boiling and are removed in the serum which rises and is taken off, consequently that iron would not be found in appreciable quantity in extract made from either beef or fish.—S. L. GOODALE.

Professor Johnson's later analyses seem to confirm the impression of Mr. Goodale

of the use of "porgy chum" as a food for sheep and poultry, stating that he had used it for five years. To prepare it for food it is prepared by drying it in the sun for two days on elevated racks, thus expelling a large portion of the water. When thus dried it will keep for an indefinitely long period. Mr. Wasson had kept a quantity in an open barrel in his barn for at least five years. One barrel, costing $2, was sufficient to feed three sheep during the entire winter. Sheep thus fed showed an average increase each of one pound and a quarter of wool, while they were constantly fat and brought heavy lambs. Hens also ate the scrap with avidity. Mr. Thomas Boyd of Boothbay, stated that hens, ducks, and turkeys prefer it to corn, and become large and heavy when fed upon it. It is customary to discontinue the scrap and feed them on corn three or four weeks previous to killing them. Professor Charles A. White inquired in regard to its effects upon the quality and flavor of the meat of animals fed with chum, stating that hogs fed in the acorn or mast region of the west do not make such firm sweet pork as those fed on corn. None of the members present were able to answer this question.

Mr. Luther Maddocks, of Boothbay, a leading manufacturer, stated that if a demand should occur for scrap to be used as animal food, it could be so pressed as to retain only 25 per cent. of water, and in that form it would be more suitable for transportation. Ordinarly it contains about 50 per cent. of water.

Apparently this subject deserves careful investigation. In the Norwegian Department in Agricultural Hall at the International Exhibition of 1876 were exhibited some biscuits made from "fish-flour," a preparation invented by the late Anton Rosing, a prominent agricultural chemist of Norway. These biscuits were in good condition after having been kept for ten years in an unsealed jar. They were intended to be applicable to the uses of soldiers, miners, and farmers, to whom a supply of fish, other than salted, is beyond reach. The editor of the American Agriculturalist suggests that a similar process might be employed in utilizing the refuse of the oil manufactories as food for stock.* The proper preparation of this material for feed, either alone or mingled with bran, corn-meal, or other products of grain, would doubtless be a great economy, both for feeding and enriching the manure.†

L.—THE MENHADEN AS A BAIT FISH.

38.—THE USE OF MENHADEN FOR BAIT.

Menhaden as cod bait.

195. Menhaden bait is extensively used in the cod and mackerel fisheries in New England and the British Provinces. Its popularity is no doubt chiefly due to the ease with which it may be obtained in large

* American Agriculturist, Vol. XXXV, 1876, p. 314.

† The value of menhaden as a food for animals is discussed more in detail by Professor Atwater in the succeeding part of this report.

quantity, though its oily nature and strong odor render it particularly well adapted for use as a toll bait for mackerel. "Slivered pogies" are carried by the "bankers" or vessels fishing for cod on the Newfoundland and George's Banks from the ports of Gloucester and Provincetown.* According to Captain Atwood, salted menhaden are good bait for haddock but inferior for cod. On the Labrador coast the bait principally used is a small fish of the salmon family known as the capelin (*Mallotus villosus*) large quantities of which are easily procured in those waters for a short period in the summer. The herring (*Clupea elongata*) is the most common bait in the Bay of Fundy cod-fisheries and it is also used by the English "bankers" to a considerable extent, as well as young mackerel. The English vessels also consume a large amount of "slivered pogies" which they buy from Massachusetts vessels. Fresh "slivers" are preferred to those which have been salted, and vessels bound to George's Banks usually carry their bait preserved on ice.

Menhaden as mackerel bait.

196. As a toll bait for the mackerel fishery, the menhaden is better than any other fish. The mackerel seem to prefer it, and the presence of a great quantity of oil renders it especially convenient for the use of fishermen, since a small quantity of ground menhaden bait will spread over a large area of water.

The introduction of the use of menhaden bait.

197. In early days it was the custom to grind up small mackerel for bait, much to the detriment of the fisheries in succeeding years. Captain Atwood remarked in his testimony before the Fishery Commission at Halifax: "We now use menhaden for bait; but when I first went fishing we did not do so. Our practice then was to grind up small mackerel for the purpose. Any quantity of these mackerel were at that time to be found along the coast and plenty of them are there to be met with now. These fish were of no account then, and so we ground them up for bait; and when we could not obtain them, we ground up for bait what you call gurry, the inwards of fish with the gills attached. American fishermen, when they fish with hooks, use menhaden bait almost exclusively. The superiority of this bait over all others is such that when this fish can get menhaden they won't take any other. At first mackerel fishermen were afraid of this bait. It is a very bony fish, and they then thought that if it was cut up for bait, the mackerel would soon get sick of it, owing to the number of bones. There is a species of fish belonging to this family found on our coast which is exceedingly fat. We call them blue-backed herrings; † and some preferred this fish for bait, as it was not so bony as the menhaden; but when the poorer

* Vessels also carry for bait "sea-clams" (*Mactra solidissima*) salted, and the common long clam (*Mya arenaria*). The former are preferred by vessels fishing off Block Island and Nantucket to supply the New York market with fresh cod and haddock. They are sold at Nantucket at the rate of 30 cents a bushel

† The alewife, *Pomolobus pseudoharengus.*

mackerel got to be worth having, about everybody adopted menhaden for bait. It is the cheapest bait." *

The comparative value of herring and menhaden for toll bait

198. Mr. Sylvanus Smith stated before the Halifax Commission: "All the bait used in mackerel fishing consists of menhaden or porgy, which is only found off the coast of the United States, and which the Canadians bought from the American fishermen to a great extent" †

Also to the same effect Mr. James G. Tarr: "The only bait used for mackerel is the porgy or menhaden, which is found entirely in the United States, and which all the Canadians have to buy from the Americans in a salted state. This fish (the porgy) is not found in Canadian waters, and is almost the only bait used in the mackerel fishery; if the Canadians were unable to procure this bait, they would be compelled to use herring bait, which is much inferior for the purpose. * * * I have known vessels to sail from this port (Gloucester) with as many as 300 barrels of porgy bait on board, which was sold in Halifax and the Straits of Canso to Canadian fishermen. * * * The bait which we buy from them for the cod-fishery consists of herring and some small mackerel." ‡

John E. Saunders remarked: "Fresh herring is used by Canadians somewhat, but it is an inferior sort of bait, and they much prefer menhaden when they can get it. * * * Canadians import menhaden bait from the United States to some extent; the menhaden is not found north of Cape Sable." §

Richard Hannan, of Gloucester, also stated: "I have sold menhaden bait to the Canadians, a few barrels each year; they import a great deal of this bait from the United States; now by the treaty they can come here and catch this bait themselves. To my own knowledge there have been two or three vessels here from Yarmouth and Argyle which came to catch porgies for use in the bay. ||

James G. McKeen, of Port Hastings, Nova Scotia, on the Strait of Canso, stated: "The bait chiefly used by American mackerel-fishing vessels is menhaden or porgies. These fish are taken, I believe, entirely on the coast of the United States, and mostly in seines within three miles of the land, so I have been informed. British mackerel fishermen use the same kind of bait principally, and depend on the United States for the supply. Clams are also used as bait for catching mackerel by both American and Colonial mackerel vessels, and they are obtained chiefly in the United States." ¶

George Critchet, of Middle Milford, Guysboro County, Nova Scotia,

* N. E. Atwood. Proceedings of Halifax Commission, Appendix L, p. 42, September 19, 1877.

† Affidavit 34. Proceedings of the Halifax Commission, 1877, Appendix M, p. 81.

‡ Affidavit 36, *op. cit.*, p. 83.

§ Affidavit 41, *op. cit.*, p. 86.

|| Affidavit 42, *op cit.*, p. 86.

¶ Affidavit 176, *op. cit.*, p. 195.

stated: "The only bait used by mackerel fishers in the Gulf of St. Lawrence is clams and porgies, and that comes all from the United States."*

Christopher Carrigan, of Lower Milford, Nova Scotia, also stated that, he has been on two trips in the north bay in provincial mackerel vessels and that they used only clams and porgies for bait.†

A similar statement was made by Martin Ryan, of Middle Milford, who had fished five seasons in provincial vessels,‡ and Philip Ryan of the same place. who stated that porgies and clams are universally used in the bay (Gulf of St. Lawrence), although a few provincial vessels may occasionally use herring. §

Andrew Laurie, of Lower Milford, also stated that herring is only used as bait when the vessels of the provincial fishermen are out of porgies and clams, which are better, ‖ and this was confirmed by Thomas England,¶ Rufus Carrigan, ** and Charles Lowrie, †† of Milford, George Laidlaw ‡‡ and R. McDonald, of Low Point, Inverness County, Nova Scotia, who remarked: "The only bait American mackerel vessels use is porgies and clams, and that is the bait nearly always used by provincial vessels, but sometimes the latter use herring, which is not a good bait and would not do at all to use as bait in fishing alongside of vessels throwing out porgies and clams." §§

Daniel McDonald, also of Low Point, stated that "ten or twelve years ago or longer there were about 400 or 500 American mackerel vessels in the bay of Saint Lawrence, and during the same time there were about 100 provincial vessels in the bay. The only bait used for mackerel, or almost the only, consists in porgies and clams, and these all come from the United States, whether used by provincials or Americans; a few English vessels use also a little fat herring, but this is used in quantities hardly worth mentioning." ‖‖

James R. Maclean, a merchant of Souris, Prince Edward Island, called on behalf of the Government of Her Britannic Majesty, sworn and examined, testified:

"Question. With regard to the bait in use for cod-fishing and mackerel, where is it obtained?—Answer. They very often use herring and sometimes porgies.

"Q. Where do they get the herring?—A. They catch them around the coast and at Labrador.

"Q. Are herring caught there?—A. Yes; there is a lot of herring taken.

* * * * * * *

"Q. The different fishermen—the large fishermen and the small fishermen—don't they all catch their own bait?—A. Yes, with nets; and for

* Affidavit 188, *op. cit.*, p. 202.

† Affidavit 189, *op. cit.*, p. 202.

‡ Affidavit 191, *op. cit.*, p. 204.

§ Affidavit 192, *op. cit.*, p. 204.

‖ Affidavit 193, *op. cit.*, p. 205.

¶ Affidavit 194, *op. cit.*, p. 205.

** Affidavit 195, *op. cit.*, p. 206.

†† Affidavit 197, *op. cit.*, p. 207.

‡‡ Affidavit 200, *op. cit.*, p. 209.

§§ Affidavit 201, *op. cit.*, p. 210.

‖‖ Affidavit 202, *op. cit.*, p. 210.

mackerel bait they take capling—a very fat little fish—and they make out that it is a better bait for mackerel than porgies.

"Q. But the large proportion of the bait is herring?—A. Yes; but they use porgies, which they often buy for bait.

"Q. To any extent?—A. The vessels which go fishing generally buy them. They prefer herring when they cannot get porgies good.

"Q. Where do they buy porgies?—A. They generally buy them on the island, where they are imported.

"Q. They buy them from the merchants?—A. Yes. It would not pay to send down to American waters to fish for porgies for the number of vessels engaged in mackerel-fishing.

"Q. They prefer to take herring, to do that?—A. Yes.*

"Cross-examined by Mr. Dana:

"Q. And your people are buying bait from the United States?—A. They sometimes do so.

"Q. You said that they very often bought pogies, which were used by your people?—A. Yes.

"Q. You mean menhaden—it is the same thing?—A. Yes.

"Q. Where do the merchants get their pogies?—A. From the States.

"Q. Do you really suppose that the American fishermen, instead of buying menhaden from first hands, would buy them of your merchants, paying their profit, and commissions, and freight, and all that?—A. Yes. I have seen these fishermen buy them when their own bait had turned sour or was bad. If the merchants have a quantity of good bait on hand, they can generally sell it.

"Q. Is that considered an article of trade?—A. No; not to a great extent.

"Q. Then the Americans get caught; their bait sometimes turns sour?—A. Yes. Consequently, of course, if out with other vessels fishing, a vessel having bad bait could not secure her share of the fish.

"Q. Can they not catch something else to be used in place of it; herring, for instance?—A. Not always. The mackerel-catchers could not wait for this. Their business is to catch mackerel.

"Q. But they can obtain it at the Magdalen Islands?—A. It would take too much time to cross at that point.

"Q. Your own fishermen could not get across any sooner?—A. No.

"Q. If you could fit out a great number of large vessels for mackerel-fishing, you would want to import a good deal of this bait, pogies or menhaden, would you not?—A. Yes; we would then, likely, import quite a lot of it. They could, however, use herring if no menhaden or poges were thrown into the fishing ground. Herring would do nearly as well.

"Q. But the fish want something better.—A. Yes."†

Mr. George Mackenzie, fisherman, of New London, Prince Edward

* Proceedings of Halifax Commission, 1877. Appendix F, p. 24.

† *Ibid.*, p. 29.

Island, witness called on behalf of the Government of Her Britannic Majesty, cross-examined by Judge Foster, testified:

"Question. There is no mistake but what the American bait is a good deal better than any other; there is no question about that?—Answer. No; it is always very well liked, but we have to pay pretty high for it.

"Q. Do you buy it?—A. Yes.

"Q. How much of it do you use?—A. I used 20 barrels last year, and I bought 20 more barrels this year, at $5 a barrel.

"Q. That makes $100 spent for manhaden bait?—A. Yes.

"Q. Do you mix this bait with herring?—A. Yes; and sometimes we mix it with clams. At the latter end of the season it is that bait which we want. When the fish are poor almost any bait will do, but when they are in good condition they require good bait.

"Q. When do you use herring bait?—A. In the spring of the year and July.

"Q. Do you mix manhaden with it?—A. Sometimes.

"Q. If it was not for its expensiveness, you would not use herrings at all?—A. No.

"Q. Do you use mills to grind the bait?—A. Yes.

"Q. And you mix the herrings and menhadens together?—A. Yes; and we also chop up clams with it."*

And, again, James McKay, deputy inspector of pickled fish at Port Mulgrave, examined by Mr. Hanson:

"Question. On your different trips mackerel-fishing, what bait do you use?—Answer. Pogies.

"Q. These are generally put up on the coast of Maine?—A. Yes.

"Q. Where would you buy them if British vessels take them?—A. Our merchants used to import them from Portland, Boston, and Gloucester.

"Q. To Port Mulgrave?—A. Yes.

"Q. And sell them as articles of merchandise?—A. Yes.

"Q. They bought and sold them?—A. The same as a barrel of flour."†

The testimony of Canadian officers.

199. H. W. Johnson, of the Department of Marine and Fisheries, wrote, in 1868, a "Special Report on the Distress among the Nova Scotia Fishermen." One of the reasons assigned by him for the failure of the fisheries is that "the pogies, the only real mackerel bait, is not caught east of Portland, and must all be imported for our fleet, the increased cost of which, added to the American duty, the fisherman has to pay on his share of fish, besides charges of transportation, place him in the position that if he catches during the season, to his own share, forty barrels of mackerel in one vessel, he has not made as good a season by about $100, gold, as if he had been in an American bottom."‡

* Proceedings Halifax Commission, 1877, Appendix F, p. 132.

† *Ibid.*, p. 190.

‡ *Ibid.*, p. 67.

Capt. P. A. Scott, R. N., commanding the marine police of the Dominion, reported, in 1870, to the Commissioner of Marine and Fisheries: "For mackerel-fishing the Americans use pogies and clams, chopped fine, as bait. The pogies are found only on the coast of the United States, and when imported into the Dominion cost about $6 per barrel."*

Capt. Charles G. F. Knowles, R. N., commanding H. M. S. "Lapwing," cruising on fishing-station No. 4, which includes the west coast of Cape Breton and the east coast of Prince Edward Island, reported to Vice-Admiral Fanshawe, November 7, 1870, in these words: "The bait with which the Americans are supplied is far superior to any which can be procured in this country, to which may be attributed in a great measure the success of the Americans previously to the recent restrictions, although, even now, the local fishermen complain that they have no chance while an American schooner is fishing near them."†

200. Professor Hind, in his treatise on the Effect of the Fishery clauses of the Treaty of Washington on the Fisheries and Fishermen of British North America (part 1, p. 75), remarks that its value as a bait for cod is, in a considerable degree, superseded by the herring; but as a bait for "tolling mackerel" it is still in repute, although other fish, similarly treated and finely ground, appear to be equally useful in this respect. The first part of this statement is undoubtedly true, at least as far as the fishermen of the British Colonies are concerned. In regard to the comparative value of herring and menhaden for toll-bait, there is still room for difference of opinion.

An average of, perhaps, 250,000 barrels of mackerel is annually caught by the United States vessels, using menhaden bait solely, against 110,000 caught by the provincial fleet, which appears to use menhaden bait when it can be obtained, buying it at the rate of $6 a barrel in preference to herring bait, which costs only the labor of catching and the salt for preserving.

Slivering menhaden.

201. The method of preparing menhaden for salting, to be used as bait, is very simple. The head of the fish is taken in the left hand of the workman, and with a knife held in the right hand he cuts a slice, longitudinally, from each side of the body, leaving the head and vertebræ to be thrown away, or, occasionally, to be pressed for oil. The slivers (pronounced *slyvers*) are salted and packed in barrels. The knife used is of a peculiar shape and is called a "slivering knife." The operation of slivering is shown in Plates XXII and XXIII.

The preparation of mackerel bait.

202. The use of menhaden bait for mackerel-fishing was inaugurated in 1835 or 1840; the bait is ground up into a mush and salted, to be used

* Third Report Commissioner Marine and Fisheries, 1871, p. 312.

† Third Report Department Marine and Fisheries, 1871, p. 342.

as a "toll-bait," and to be thrown over the side of the smack to attract the school to the surface and to keep it alongside; this is called "chumming up the fish," and the bait is called "chum" or "stosh." To prepare it for use the "slivers" are passed through a "bait-mill," which is a machine like a farmer's feed-cutter; the fish are thrown into the hopper, from which the fish pass between a roller armed with small knives in rows, and a series of similar knives arranged along a board which slopes toward the bottom. The bait is usually ground at night, by the watch on deck; when the vessel has no "bait-mill," the fish are cut up with a hatchet or scalded with boiling water in a tub. Bait-mills were first introduced about the year 1824. In fishing for mackerel, one man throws over the bait while the rest ply their lines. "Toll-bait" is also used by the smacks, which use purse-seines and drift-nets, to attract the fish to the surface.

The use of menhaden bait in the coast fisheries.

203. Menhaden bait is also used in the coast fisheries for sea-bass, on the "bull-tows" or "trot-lines," and in the eel and lobster pots. They are not much in favor for the latter use, however, for the oil of the fish is thought to permeate the flesh of the lobster, imparting to it an unpleasant flavor.

Extent of bait-fishery in New England.

204. Captain Babson, of Gloucester, whose account of the bait-fishery of Cape Ann is quoted elsewhere, and to whom I am indebted for much other valuable information, informs me that there were over 60,000 barrels of "round fish" taken in his district in 1873. Vessels belonging to the companies of the Maine Oil and Guano Association sold in 1873 for bait 2,977 barrels; in 1874, 10,400; in 1877, 10,795. From the bait fisheries about Marblehead, in the vicinity of Provincetown, 1,000 to 2,000 barrels were taken for bait in 1873, according to Mr. Loring. At Chatham, for the past five years, the average catch has been about 5,000 barrels, a large portion of which are sold to the George's Bank codfish vessels. Nothing has been heard from the bait fisheries about Nantucket, which are, however, quite unimportant.

A large part of the fish taken at Martha's Vineyard are used for bait; in 1873 there were 5,000 barrels according to Jason Luce & Co.

At Gloucester, according to Mr. Babson, the 60,000 round barrels of fish make 20,000 barrels of "slivers," worth $4 per barrel to the producer. At Marblehead, it averages $1 per barrel for fresh and $6 for salt; at Chatham, $1.50 fresh; at Nantucket, 50 cents to 75 cents, and at Martha's Vineyard 50 cents, as I am told. In Narragansett Bay, according to Mr. J. M. K. Southwick, bait sold in 1871 for $1 and $1.50.

Bait-fishery in Merrimac River and Salem Harbor.

205. Fisheries of some importance are carried on at the mouth of the Merrimac River. The menhaden thus obtained are used chiefly to sup-

ply the Cape Ann fishing fleet with bait, although they are salted for food to a considerable extent. Ten seines and about seventy men are engaged in this fishery during its continuance, which is usually about one month—from the middle of June to the middle of July. The seines are 100 to 200 yards long and 5 to 8 fathoms deep, requiring 6 to 8 men to manage them. The boats from which they are worked are light scows, about 25 feet in length, and 8 feet in breadth of beam. The seine is set from the stern of the scow, and is worked from the shore by means of long warps.

Capt. Moses Pettingell, of Newburyport, to whom I am indebted for the above facts, tells me that the seine-gangs have occasionally taken 2,000 barrels of fish in a single day.

Boston and Gloucester vessels come to anchor at the mouth of the river and wait for their supplies of bait. At one time in 1877 there were 25 fishing schooners waiting. Captain Pettingell estimates that 500 supplies of bait of from 10 to 60 barrels are sold annually by the Merrimac seine-gangs.

The regular price of fresh bait for the past ten years has been $1 per barrel. Probably 1,000 barrels of slivered fish were prepared in 1876; these sold for $5 per barrel. Captain Pettingell estimates the annual catch for 1876 at 2,000 barrels to a boat, making an aggregate catch of 20,000 barrels, or perhaps 6,600,000 fish. The returns are probably not far from $20,000 in a good season.

The following table is from the Report of the Commissioners of Inland Fisheries for 1877 (p. 65). It is possibly not complete:

TABLE.—*Seine fishery at mouth of the Merrimac.*

Name.	Menhaden.
E. Thurlow	2,013,675
R. Pierce	
B. M. Perkins	
W. H. H. Perkins	
N. Lattime	
B. Stevens	

A similar fishery, though of much less extent, is carried on by Gloucester vessels in Salem Harbor. There being no considerable body of fresh water, the schools are small and are easily dispersed. July 15, 1877, I observed six or seven gangs busily plying their seines opposite The Willows. After a day or two the menhaden were driven away, and the fishing ceased until the following week, when they returned and were soon followed by the same boats.

An estimate of the total consumption of menhaden bait.

206. It is not practicable to make, from the data to which I have access, any very accurate estimate of the total quantity of menhaden

bait used in one year. I have given below a number of estimates for individual ports or fisheries; 60,000 round barrels are thus accounted for. I do not hesitate to estimate the total consumption for 1877 at 80,000 barrels, or 26,000,000 of fish.

Consumption by the George's Banks fleet.

207. The George's Banks cod fleet is owned entirely in Gloucester There are about 130 vessels, making usually one trip every twenty days. When they can get slivered menhaden they carry no other bait. Early in the summer they go to the Vineyard Sound for their bait, where they buy it from the pounds; later they are able to buy it from Gloucester and Newburyport seines. Each vessel carries about 40 round barrels of menhaden, iced. Mr. Joseph O. Proctor estimates the annual number of trips made with this bait at 600. This gives a total amount of 24,000 round barrels, or about 8,000,000 of fish; 24,000 round barrels are equivalent to 8,000 barrels of slivered fish.

Ten years ago, according to the estimate of the same gentleman, the "Georgiamen" did not carry menhaden bait on so many trips, nor did they carry so much. He estimates 300 trips, at 30 barrels each, giving an aggregate of 9,000 round barrels, or about 3,000,000 fish.

Consumption by the Grand Banks fleet.

208. Mr. Proctor estimates that the Grand Bank cod vessels of Gloucester use in all about 600 barrels of slivered menhaden bait.

Major Low's statement of the outfit of the schooner "Madam Roland,"* copied from the trip-book, shows that she was supplied with 5 barrels of pogie slivers, at $8 per barrel, making $40; and 5 barrels of slack-salted clams, at $11, making $55.† His model table, to show the cost of a new schooner fitted at Gloucester, 1875, for a four months' trip to the Grand Banks for codfish and halibut, with 14 hands, estimates for 12,000 pogies or herring, at $100.‡

Consumption by the mackerel line-fishermen.

209. Each mackerel-vessel engaged in line-fishing consumes during the course of the season about 20 barrels of salted menhaden slivers. In 1867, when the entire fleet fished with hooks, the amount consumed by Gloucester alone amounted, by Mr. Proctor's estimate, to 6,500 barrels, and the total consumption in the United States of mackerel bait must have exceeded 25,000 barrels. In 1877 the purse-seiners are in a large majority. The whole amount consumed by a seining-vessel does not exceed 5 or 6 barrels in a season. Gloucester had in 1877 about 60 "mackerel-hookers," using about 2,400 barrels of slivers, while its seining-fleet used about 2,000 barrels more.

---

* Sailed for the Grand Banks August 26, 1873; arrived at Gloucester October 10, 1873; time absent, one month fourteen days; gross stock, $2,758.27.

† *Ibid.*, p. 362.

‡ *Ibid.*, p. 368.

Capt. Sylvanus Smith, of Gloucester, stated to the Halifax Commission that a vessel fitting out for a four months' trip to the Gulf of St. Lawrence would need to be supplied with 40 barrels of pogie bait, worth $6 a barrel, making $240, and 10 barrels of salt clams, worth $8 a barrel, making $80.*

Major Low's statement, copied from the trip-book of the schooner Oliver Eldridge,† shows that she fitted out with 55 barrels of slivered pogies, at $6.50 a barrel, making $357.50, and 7 barrels of clams, at $6, making $42.‡

The amount of these outfits is much greater than that upon which the above estimate was made.

The entire amount used in the mackerel fishery in 1877 probably did not exceed 8,000 or 9,000 barrels of slivers, or 24,000 to 27,000 barrels of "round fish."

Consumption by the Connecticut smacks.

210. There are seven Connecticut smacks fishing for the flounder (*Chaenopsetta ocellaris*) in Long Island and Block Island Sounds. Five of these hail from Noank, one from Mystic, and one from New London. Captain Ashby tells me that these smacks average one trip every four or five days for five months (May to September inclusive). They use only menhaden bait; about one barrel each trip, or perhaps 150 barrels in the season.

Sixteen Noank and four New London smacks fish for sea-bass. Each carries two or three barrels of menhaden bait each trip, making an aggregate annual amount of about 1,000 barrels.

Consumption by the New York halibut fleet.

211. The New York halibut fleet of 11 sails, owned at Noank, New London, and Greenport, uses only menhaden bait, which is iced fresh in the vessels' holds. Each vessel carries from 6,000 to 10,000 fish each trip. Each vessel makes five or six trips. The aggregate number of menhaden thus used is perhaps 480,000, or 1,400 barrels. The usual price is $4 a thousand.

Annual sale of bait by the Maine manufacturers.

212. The Menhaden Oil and Guano Manufacturing Association of Maine sold for bait:

	Barrels of fish.
In 1873	2,977
In 1874	10,400
In 1875	10,752
In 1876	8,432
In 1877	10,795

* Proceedings Halifax Commission, 1877, Appendix L, p. 334.

† Which sailed for the Bay of St. Lawrence August 5, 1875 (absent 2 months and 28 days), arrived at Gloucester November 2, 1875, stocking $1,771.83, or 224 barrels of mess mackerel.

‡ *Ibid.*, p. 334.

The Connecticut method of icing bait.

213. A peculiar method of preserving the unsalted menhaden is made use of on board of the Connecticut halibut-catchers. The fish, after being very carefully cleaned and eviscerated, are packed with pounded ice in bins holding about 125 cubic feet (about 5 feet in each dimension). A ground-layer of ice-blocks 12 inches thick is first laid, then a tier of fish consisting of two layers and about 4 inches thick, then a layer of 4 inches of pounded ice, and so on until the bin is filled, after which its sides are packed with pounded ice and covered with canvas. Seven to ten thousand fish are thus stowed in one bin. The stowing having been completed, the fish and ice freeze together in a solid mass, which is left untouched until the fishing-banks are reached.

Their supply of bait being thus secured, the vessels are never obliged to make harbor in search of a new supply. They often catch their fare upon La Have or Brown's Bank, and return home without having anchored. The bait is good for three weeks. Captain Ashby assures me that he has used it on the thirty-third day.

The Cape Ann method of icing bait.

214. On board the Gloucester vessels the menhaden are not eviscerated, nor are they packed with so much care; consequently they never last more than three weeks. Since twenty-four hours or more are usually occupied on both outward and home voyages, there is only a short time left for which the supply of bait can be counted upon. If by any means this time could be doubled, an important advantage would be acquired. Vessels would often be able to complete their fares on the eastern banks without going to Newfoundland for bait. Does the Connecticut method fulfill this requirement? Captain Hurlbert, one of the most experienced fishermen of Gloucester, says no. He claims that neither cod nor halibut will bite well at a fish which has had its blood removed. He says that a half-decayed fish, with the blood still in it, is better bait than a perfectly sweet one kept by cleaning it. He says, still further, that Gloucester fishermen formerly followed this method, but that it was abandoned many years ago, as early as 1866.

The comparative value of various methods of icing.

215. The comparative value of the different methods of preserving bait was discussed by Professor Baird in his testimony before the Halifax Commission, which is quoted:

"Question. Now will you state what observation you have made respect ing the method of preserving fresh bait from the start all the voyage through?—Answer. As a general rule it is now preserved either by salting or freezing. Of course they keep it as long as it will remain without spoiling, and when you have to carry it beyond that time either ice it or salt it. Salting, of course, is a very simple process, but it alters

materially the texture and taste to such a degree that fish or other bait that under certain circumstances is highly prized by the fish is looked upon with a great deal of indifference when salted. Now, there are special methods of preserving the fish or bait by some chemical preparation, which preserves the fish without giving the saline taste. There are preparations by means of which oysters or clams or fish can be kept in solutions for six months without getting any appreciable taste, and without involving the slightest degree of deterioration or destruction. One process submitted to the group of judges, of whom I was chairman, was exhibited by an experimenter, who placed a jar of oysters in our room prepared in that way. I think about the 1st of August those were placed in our room, and they were kept there until the middle of September, for six weeks during the hottest portion of the Centennial summer, and that was hot enough. At the end of that time we mustered up courage to pass judgment upon this preparation, and we tasted these oysters and could not find them affected. We would have preferred absolutely fresh oysters, but there was nothing repugnant to the sensibilities, and I believe we consumed the entire jar. And we gave the exhibitor, without any question, an award for an admirable new method. That man is now using that process on a very large scale in New York for the preservation of fish of all kinds, and he claims he can keep them any length of time and allow them to be used as fresh fish quite easily. I don't suppose any fisherman ever thought of using any preservative except salt.

"Q. That is entirely experimental?—A. It is experimental, but it promises very well. Now, borax is one of the substances that will preserve animal matter a great deal better than salt, and without changing the texture. Acetic acid is another preparation, or citric acid will keep fish a long time without any change of the quality, and by soaking it in fresh water for a little while the slightly acidulated taste will be removed. I don't believe a cod will know the difference between a clam preserved in that way and a fresh clam.

"Q. Now, about ice. We know a good deal has been done in the way of preserving bait in ice. How far has that got?—A. It is a very crude and clumsy contrivance. They generally break up the ice into pieces about the size of pebble stones, or larger; then simply stratify the bait or fish with this ice, layer and layer about, until you fill up a certain depth or distance. The result is that if the bait can be kept two weeks in that method it is doing very well. They generally get a period of preservability of two weeks. The ice is continually melting and continually saturating the bait or fish with water, and a very slow process of decomposition or disorganization goes on until the fish becomes musty, flabby, and tasteless, unfit for the food of man or beast.

"Q. Well, there is a newer method of preservation, is there not?—A. There is a better method than using ice. The method described by the Noank witness, by using what is equivalent to snow, allows the water

to run off or to be sucked up as by a sponge. The mass being porous prevents the fish from becoming musty. But the coming methods of preserving bait are what is called the dry-air process and the hard-freezing process. In the dry-air process you have your ice in large solid cakes in the upper part of the refrigerator and your substance to be preserved in the bottom. By a particular mode of adjusting the connection between the upper chamber and the lower there is a constant circulation of air, by means of which all the moisture of the air is continually being condensed on the ice, leaving that which envelopes the bait or fish perfectly dry. Fish or any other animal substance will keep almost indefinitely in perfectly dry air about 40° or 45°, which can be attained very readily by means of this dry-air apparatus. I had an instance of that in the case of a refrigerator filled with peaches, grapes, salmon, a leg of mutton, and some beefsteaks, with a great variety of other substances. At the end of four months in midsummer, in the Agricultural Building, these were in a perfectly sound and prepossessing condition. No one would have hesitated one moment to eat the beefsteaks, and one might be very glad of the chance at times to have it cooked. This refrigerator has been used between San Francisco and New York, and between Chicago and New York, where the trip has occupied a week or ten days, and they are now used on a very large scale, tons upon tons of grapes and pears being sent from San Francisco by this means. I had a cargo of fish-eggs brought from California to Chicago in a perfect condition. Another method is the hard-frozen process. You use a freezing mixture of salt and ice powdered fine, this mixture producing a temperature of twenty degrees above zero, which can be kept up just as long as occasion requires by keeping up the supply of ice and salt.

"Q. How big is the refrigerator?—A. There is no limit to the size that may be used. They are made of enormous size for the purpose of preserving salmon, and in New York they keep all kinds of fish. I have been in and seen a cord of codfish, a cord of salmon, a cord of Spanish mackerel, and other fish piled up just like cord-wood, dry, hard, and firm, and retaining its qualities for an indefinite time.

"Q. Well, can fish or animals be kept for an unlimited period if frozen in that way?—A. You may keep fish or animals hard dried frozen for a thousand years or ten thousand years perfectly well, and be assured there will be no change.

"Q. Have geologists or paleontologists satisfied themselves of that by actual cases of the preservation of animal substances for a long period?—A. Yes; we have perfectly satisfactory evidence of that. About fifty years ago the carcass of a mammoth, frozen, was washed out from the gravel of the river Lena, I think, one of the rivers of Siberia, and was in such perfect preservation that the flesh was served as food for the dogs of the natives for over six months. Mr. Adams, a St. Petersburg merchant, came along on a trading expedition, and found it nearly con-

sumed, and bought what was left of it for the St. Petersburg Academy of Science—the skeleton and some portion of the flesh—which were preserved first in salt and afterwards in alcohol. Well, we know the period of time that must have elapsed since the mammoth lived in the arctic circle must be very long. We know we can talk with perfect safety of ten thousand years. The geological estimate of it is anywhere from fifty to a hundred thousand years; we cannot tell. There is no unit of measure; we know it must have been some hundreds of thousands, and probably it would have remained in the same condition as much longer.

"Q. Now, to come to a practical question, is this a mere matter of theory or of possible use? For instance, could this method be adapted to the preservation of bait for three or four months if necessary?—A. The only question of course is as to the extent. There is no question at all that bait of any kind can be kept indefinitely by that process. I do not think there would be the slightest difficulty in building a refrigerator on any ordinary fishing-vessel, cod or halibut, or other fishing-vessel, that should keep with perfect ease all the bait necessary for a long voyage. I have made some inquiries as to the amount of ice, and I am informed by Mr. Blackford, of New York, who is one of the largest operators of this mode, that to keep a room ten feet each way, or a thousand cubic feet, at a temperature of 20° above zero would require about 2,000 pounds of ice and two bushels of salt per week. With that he thinks it could be done without any difficulty. Well, an ordinary vessel would require about seventy-five barrels of bait, an ordinary trawling vessel. That would occupy a bulk something less than 600 feet, so that probably four and a half tons of ice a month would keep that fish. And it must be remembered that his estimate was for keeping fish in midsummer in New York. The fishing-vessels would require a smaller expenditure of ice, as these vessels would be surrounded by a colder temperature. A stock of ten to twenty tons would, in all probability, be amply sufficient both to replace the waste by melting and to preserve the bait."*

39.—Conflicts between bait fishermen and others.

Early feuds.

216. Some jealousy has naturally arisen at times between the bait-fishermen and the manufacturers, as is shown by the following extract from Professor Johnston's "History of the Towns of Bristol and Bremen, in the State of Maine."

A special branch of the fishing business has of late been undertaken quite largely here (in Bristol), as at other places on the New England coast, called the "porgey fishery." The fish are taken in seines, usually several miles from the coast, and are used for the oil they produce, and for manure.

* Proceedings Halifax Commission, Appendix L, p. 457.

These fish, the common menhaden of the coast, have been caught for use as bait in the cod-fishery from the earliest times; and at first the new branch of industry, in which such immense quantities are consumed, was viewed by the old fishermen with no little suspicion, as likely to interfere with the important and older branch of the fishing business by depriving them of bait. Some riots were at least threatened, and one oil factory was actually destroyed, as was believed, by the old fishermen, or at their instigation; but the opposition has ceased, and the general opinion seems to be that it is best to foster such an extensive branch of business, giving profitable employment for a part of the season, as this does, to so many men, even though it may be attended by some disadvantages, which in the end may prove more imaginary than real.*

The present aspects of the conflict in Maine.

217. In 1877 and 1878 a determined effort was made by the Maine line-fishermen to secure the passage of a legislative act forbidding the use of seines near the shores. Their claim was that the present methods employed in the fishery interfered with their legitimate privilege of catching menhaden for bait, and that their tendency was to drive away all other fishes as well, and to destroy the fisheries.

To this movement the manufacturers made strenuous opposition, claiming that the menhaden fishery is practically inexhaustible; that the habits of the species have not been changed by the fishery, and that so far from making it difficult to obtain bait the large fishery made it easier, capturing it in great masses and selling it to the fishermen in any desired quantity cheaper than they could obtain it for themselves. Mr. Maddock's report, which has frequently been mentioned, was prepared at the wish of the Maine manufacturers as an argument to be presented to the legislature on their behalf. All the questions involved have been elsewhere discussed. It seems very unlikely that any legislature will at present interfere with so extensive an interest as that of the menhaden oil manufacturers.†

40.—MENHADEN BAIT AS AN ARTICLE OF COMMERCE, AND THE CONSIDERATION OF ITS VALUE BY THE HALIFAX COMMISSION OF 1877.

The export of bait to the Dominion.

218. In the section relating to the value of the menhaden as a bait-fish (paragraphs 186–190), allusion was made to its extensive exportation for use in the fisheries of the Dominion of Canada.

The evidence of several witnesses was quoted to prove that menha-

* A History of the Towns of Bristol and Bremen in the State of Maine, including the Pemaquid Settlement. By John Johnston, LL. D., a native of Bristol, and Professor Emeritus of Natural Science in the Wesleyan University, Middletown, Conn., and Cor. Mem. of the Maine Historical Society. Albany, N. Y. Joel Munsell. 1873. 8vo. pp. 524. p. 460.

† See paragraph 156.

den bait was preferred to any other kind by the provincial fishermen. I am told that a considerable number of the vessels of the New England fleet fishing in the Gulf of St. Lawrence are accustomed to carry partial cargoes of salted menhaden to sell in the Straits of Canso. I have been unable to obtain any satisfactory statistics of this exporting trade. This is doubtless due to the fact that every mackerel vessel carries twenty barrels or more of salt slivered fish, and there being no law requiring their entry in the custom-house or for reporting sales after the return of the vessel, no one has the data upon which to found an estimate. More than 5,000 barrels of slivered menhaden, worth more than $30,000, were probably carried to Dominion waters during the past season. Many vessels doubtless expended all the bait which they carried; many others sold their surplusage to the provincial mackerelmen. I should hardly venture to estimate the amount of these sales at more than $8,000 or $10,000, and very possibly they are even less extensive.

The claim of the English Government.

219. The subject of the alleged trade in menhaden bait was referred to frequently in the course of the proceedings of the Halifax Commission of 1877. The subject was first introduced by the English counsel in the "Case of Her Majesty's Government," * as follows:

"The question of bait must now be considered, as some importance may, perhaps, be attached by the United States to the supposed advantages derived in this respect by British subjects. It might appear at first sight that the privilege of resorting to the inshores of the Eastern States to procure bait for mackerel-fishing was of practical use. Menhaden are said to be found only in the United States waters, and are used extensively in the mackerel-fishing, which is often successfully pursued with this description of bait, especially by its use for feeding and attracting the shoals. It is, however, by no means indispensable; other fish-baits, plentiful in British waters, are quite as successfully used in this particular kind of fishing business, and very generally in other branches, both of deep-sea and inshore fishing, as, for example, fresh herrings, alewives, capelin, sandlaunce, smelts, squids, clams, and other small fishes caught chiefly with seines close in shore. British fishermen can thus find sufficient bait at home, and can purchase from American dealers any quantities they require much cheaper than by making voyages to United States waters in order to catch it for themselves. It is a remarkable fact that for six years past American fishermen have bought from Canadians more herring bait alone than all the menhaden bait imported into Canada during the same period. The menhaden bait itself can also be bred and restored to places in the Bay of Fundy, on the western coast of Nova Scotia, where it existed up to the time of its local extermination."

* Proceedings of the Halifax Commission, Appendix A, p. 28.

And again: "It is notorious that the supply both of food and bait fishes has become alarmingly scarce along the United States coast. At Gloucester alone some thirty vessels are engaged during about six months in each year catching menhaden for bait. They sell about $100,000 worth annually, and, by catching them immoderately in nets and wears for supplying bait and to furnish the oil mills, they are rapidly exterminating them. The Massachusetts Fishery Commissioners, in their report for 1872, state that 'it takes many hands working in many ways to catch bait enough for our fishing fleet, which may easily be understood when it is remembered that each George's man takes fifteen or twenty barrels for a trip, and that each mackereler lays in from 75 to 120 barrels, or even more than that.' One of the principal modes for the capture of bait and other fishes on the New England coast is by fixed traps or pounds on the shore. By means of these, herrings, alewives, and menhaden are caught as bait for the sea-fishery, besides merchantable fish for the markets, and the coarser kinds for the supply of the oil factories. There are upward of sixty of these factories now in operation on the New England coast. The capital invested in them approaches $3,000,000. They employ 1,197 men, 383 sailing vessels, and 29 steamers, besides numerous other boats. The fish material which they consume yearly is enormous, computed at about 1,191,100 barrels, requiring whole fishes to the number of about 300,000,000. These modes of fishing for menhaden and other bait are, furthermore, such as to preclude strangers from participating in them without exceeding the terms of the treaty; and even without this difficulty it must be apparent that such extensive native enterprises would bar the competition and suffice to ensure the virtual exclusion of foreigners."

The reply of the agent of the United States.

220. In the "Answer on behalf of the United States of America to the case of Her Britannic Majesty's Government,"* Judge Foster, states: "Off the American coast are found exclusively the menhaden or porgies, by far the best bait for mackerel."

This is well stated by Sir John MacDonald (in a debate in the Dominion Parliament, May 3, 1872), who says:

"It is also true that, in American waters, the favorite bait to catch the mackerel is found, and it is so much the favorite bait that one fishing vessel having this bait on board would draw a whole school of mackerel in the very face of vessels having an inferior bait. Now, the value of the privilege of entering American waters for catching that bait is very great. If Canadian fishermen were excluded from American waters by any combination among American fishermen or by any act of Congress, they would be deprived of getting a single ounce of the bait. American fishermen might combine for that object, or a law might be passed by Congress forbidding the exportation of menhaden; but, by the provision

* Proceedings of the Halifax Commission, Appendix B, pp. 18, 19.

made in the treaty, Canadian fishermen are allowed to enter into American waters to procure the bait, and the consequence of that is, that no such combination can exist, and Canadians can purchase the bait, and be able to fish on equal terms with the Americans."

These statements were based upon the Canadian official reports previously published, which say:

"For mackerel, the Americans use 'pogies' and clams, chopped fine, as bait. The 'pogies' are found only on the coast of the United States, and, when imported into the Dominion, cost about $6 per barrel.

"The bait with which the Americans are supplied is far superior to any which can be secured in this country, to which may be attributed in a great measure the success of the Americans previously to the recent restrictions, although even now the local fishermen complain that they have no chance while an American schooner is fishing near them."*

"The menhaden fishery has within ten years grown into an immense business. Formerly they were taken only for bait, and were either ground in hand-mills, for mackerel, or used in what is called "slivers" for codfish bait. There is now a large fleet of steamers and sailing-vessels engaged in this fishery. Large factories have been erected on shore for extracting the oil. As these fish are not valuable until they are fat, which is in August and September, they are not much taken in their spawning time; and they will not therefore be exterminated. They are caught solely with seines, near the shore, their food being a kind of marine seed which floats upon the waters; consequently they will not take the hook. This fishery is one of the most profitable of all the fisheries, the oil being used for tanning and currying, extensively at home, and being exported in large quantities. The refuse of the fish, after being pressed, is used for manufacturing guano or fish phosphate, and is very valuable as a fertilizer. This fishery is purely an American fishery, no menhaden ever being found north of the coast of Maine. It is entirely an inshore fishery, the fish being taken within two miles from the shore."

The reply of Her Britannic Majesty's Government.

221. The "Reply on behalf of Her Britannic Majesty's Government to the Answer of the United States of America" responds:

"The Answer (pp. 18 and 19) lays much stress on the importance to Canadian fishermen of the menhaden bait-fishery on the coast of the New England States. The menhaden is here represented to be the best bait for mackerel, and is said to inhabit exclusively the American coast. An entirely fictitious value has been attached to this fishery. British fishermen do not frequent United States waters for the purpose of catching bait of any kind, or for any other purposes connected with fishing, consequently the privilege of entering those waters to catch menhaden is of no practical value. Any bait of that description which they may require may be purchased as an article of commerce.

*Annual report of the Department of Marine and Fisheries for the year ending June, 1870, pp. 312, 342.

"There are not now, nor have there ever been, treaty stipulations to prevent British fishermen from entering American waters to buy bait, if they prefer to do so. As a matter of fact, whatever menhaden bait British fishermen use is either purchased from American dealers or from Canadian traders, who import and keep it for sale like any other merchandise. Reference is made in the Answer to the possible contingency of legislation prohibiting the export or sale of menhaden-bait, the implied consequence being a serious disadvantage to Canadian fishermen in prosecuting the mackerel fishery. It would, in such contingency, be necessary to use other baits equally good, or resort to some other method of fishing, such as that described at page 10, enabling the fishermen to dispense with bait. Moreover, it is well known that menhaden are now caught in the open sea, many miles distant from the American coast. The Answer asserts, at page 19, that 'it is entirely an inshore fishery.' It can be proved that menhaden are chiefly caught off shore, frequently 'out of sight of land.'"

Mr. S. L. Boardman, of Augusta, Me., in an interesting report to the State Board of Agriculture, of which he is secretary, published in 1875, at page 60, says:

"Parties engaged in taking menhaden now go off ten or twenty miles from shore, whereas they formerly fished near the coast, and they now find the best and 'most profitable fishing at that distance.' This fish is included among the shore fishes described by Prof. S. F. Baird as having suffered 'an alarming decrease' along the inshores of the United States, owing partly to excessive fishing throughout their spawning time in order to supply the oil-factories."

Chapter 5 of the Answer deals with "the specific benefits which the treaty directs the Commission to regard in its comparison and adjustment of equivalents." The admission of Britsh subjects to United States fishing grounds has been dealt with at length in the third chapter of the Case. There is nothing in the Answer on this subject calling for any reply excepting the statement at page 20, that Dominion fishermen "have in the United States waters to-day over 30 vessels equipped for seining, which in company with the American fleet are sweeping the shores of New England." Leaving out of question the "American fleet," which has nothing whatever to do with the matter, the correctness of the statement is directly challenged in so far as it implies that these 30 vessels or any of them are British bottoms, owned by Dominion fishermen; and the United States is hereby called upon to produce evidence in its support.

References in the testimony and affidavits.

222. In the testimony and affidavits presented by the United States counsel,* referred to in the biography of the menhaden appended to this memoir and quoted to some extent in paragraphs 188–189, are many

* Proceedings of the Halifax Commission, Appendices L and M.

allusions to the value of menhaden bait. In the series of statistical tables filed* is given a statement, prepared by the writer, of the annual product of the menhaden fisheries. In the speeches of counsel during the session of the Commission very little attention was paid to the menhaden.

Mr. Dana's remarks in his argument.

223. Mr. Dana remarked in his closing argument: †

"We need not catch our mackerel bait any more than our cod bait, within the three-mile limit. On the contrary the best mackerel bait in the world is the menhaden, which we bring from New England. All admit that. The British witnesses say they would use it, were it not that it is too costly. They have to buy it from American vessels, and they betake themselves to an inferior kind of bait when they cannot afford to buy the best from us."

224. Few comments are needed upon these statements.

(1) While other fish than the menhaden *may* be used as bait, the latter is preferred by mackerel fishermen generally. (See quotations from affidavits of Nova Scotian fishermen quoted above, 186–190, and the depositions of numerous American fishermen before the Commission referred to in the Bibliography of the Species, Appendix C.)

(2) For the period of six years past, referred to in the comparison of the sales of menhaden bait and herring bait, the mackerel fisheries in Canadian waters have been far below their usual importance, and there has been no large demand for menhaden bait. The bank cod-fishery has been as successful as usual and the demand for herring bait undiminished. Moreover a large proportion of the frozen herring exported to the United States are consumed as food, not as bait.

(3) The claim that the menhaden are being rapidly exterminated is discussed above in paragraphs 151–156.

(4) The criticism by the British counsel of the statement that menhaden are not taken at a distance from the shore is well sustained.

(5) The very extraordinary statement that menhaden can be bred and restored to their former haunts in the waters of Nova Scotia may be met by the statement that there is no evidence that the species was ever other than an accidental visitor to those waters, that none have been seen there for the past twenty-five years, that the present eastern limit of the geographical range of the species is forty or fifty miles west of—

M.—THE MANUFACTURE OF OIL AND GUANO.

41.—A HISTORY OF THE OIL MANUFACTURE.

The claims of Maine to the discovery of menhaden oil.

225. The manufacture of menhaden oil has been prosecuted for a few years only. Several individuals claim the honor of having been first to

* *Ibid.*, Appendix O.

† Appendix J, p. 78.

discover its value. About the year 1850 Mrs. John Bartlett, of Blue Hill, near Mount Desert, Me., while boiling some fish for her chickens noticed a thin scum of oil upon the surface of the water. Some of this she bottled, and when on a visit to Boston soon after carried samples to Mr. E. B. Phillips, one of the leading oil merchants of that city, who encouraged her to bring more. The following year the Bartlett family industriously plied their gill-nets and sent to market thirteen barrels of oil, for which they were paid at the rate of $11 per barrel, in all $143.*

Mr. Phillips gave them further encouragement, furnishing nets and large kettles, which they set up out of doors in brick frames, for trying out the fish. It was thought that much oil was thrown away with the refuse fish or scrap, and the idea of pressing this scrap was suggested. This was at first accomplished by pressing it in a common iron kettle with a heavy cover and a long beam for a lever; afterward by placing it under the weight of heavy rocks, in barrels and tubs perforated with auger holes. Mr. Phillips subsequently fitted out some fifty parties on the coast of Maine with presses of the model known as the "screw and lever press."

The claims of Connecticut and New York.

226. Others claim to have manufactured oil about the same time.† It is said that as early as 1850 or 1852 there was an establishment for the manufacture of white-fish oil near old Fort Hale, New Haven Harbor. I am informed that Elisha Morgan, of Poquannock Bridge, Conn., made oil from bony fish previous to the year 1850. He owned seines with which he caught fish to be spread upon land fresh. When he could not sell all his fish to the farmers he extracted their oil by boiling them.

Whether the value of the article and the methods of manufacture were first brought to notice in Maine or not, the people of that State were slow to improve their opportunities and the trade first assumed its importance on the shores of Long Island Sound. Whether the fisherman's wife of Blue Hill is the sole discoverer of the properties of menhaden oil is not evident; perhaps the facts were also known to others. At any rate the tradition of the Bartlett family is not current on Long Island. In the year 1850, according to Captain Sisson, D. D. Wells and

* As this account is somewhat different from those hitherto published, I give the story in the words of Mr. E. B. Phillips himself: "In about 1850 I was in the fish-oil business in Boston. An elderly lady by the name of Bartlett, from Blue Hill, Me., came into my store with a sample of oil, which she had skimmed from the kettle in boiling menhaden for her hens. She told me that the fish were abundant all summer near the shore, and I promised $11 per barrel for all she could produce. Her husband and sons made thirteen barrels the first year, and the following year one hundred barrels."

† The manufacture of oil and of artificial guano from fishes has long been practiced in France, where the fish called Merlan (*Gadus merlangus*) is employed for the purpose, yielding 1½ to 2 per cent. of oil. In France the fish cake remaining after the extraction of oil is dried at a steam heat and is then ground fine and packed in air-tight casks for sale as manure.

his son Henry E. Wells started the first factory in the vicinity of Greenport, using steam for making oil and scrap. "At that time there were some few pots (whalemen's try-pots) used by other parties in boiling the fish in water and making a very imperfect oil and scrap, but were not very successful. The first oil made by D. D. Wells & Son was very black, impure, full of fleshy matter, and had a very offensive smell. It did not come much into use, and for a long time the profits of the business were small; but by persistent effort in perfecting machinery the quality of the oil was so much improved as to come into general use for certain purposes, such as painting, tanning, manufacture of rope, and adulterating other oils. The scrap was also very much improved by grinding and drying, pulverizing, &c., so that during the war the business was quite remunerative. At that time quite a number of factories were established and for a time the business was somewhat overdone, which caused some to abandon it altogether, and others to consolidate; and at the present time there are ten factories in operation, doing a fair business, giving employment to a large number of people and bringing up a hardy race of boatmen and sailors."

Professor Baird, visiting this region in 1857, wrote: "Quite recently several establishments have been erected on Long Island for the manufacture of oil from the moss-bunker. The fish, as brought in, are chopped up and boiled, and the oil skimmed off; a heavy pressure on the residuum expresses the remaining oil, and what is left is still useful as a manure. The oil finds a ready market. It has been estimated that a single fish will furnish enough oil to saturate a surface of paper eighteen inches square."*

Notwithstanding the fact that the coast of Maine was adapted for much more profitable prosecution of the oil manufacture, nothing of importance was done there until 1865. The trade grew rapidly for about four years, but has not augmented considerably since 1870. Twenty factories were built in a short period, fourteen of which are still in operation, though several have failed from the too sudden expansion of their business. As has been seen, the only points at which the trade has any statistical importance are within a limited area on the coast of Maine, on Narragansett Bay, and on Long Island Sound. At other points, one or two factories absorb the whole business; they are but half worked, and many of them have been abandoned. I am informed that efforts are being made to establish factories on Cape Cod and on the coast of South Carolina.

Great improvement has been made in the processes of refining and clarifying the oil, and the clear, yellow, nearly odorless substance now produced is vastly different from the article manufactured in early days.

The process of extracting oil by steam was patented in 1852 or 1853 by Wm. D. Hall, of Wallingford, Conn., the originator of the Quinnipiac Fertilizer Company. Mr. Hall was engaged in bone-boiling and tallow-

* Fishes of the New Jersey Coast, 1855, p. 33.

rendering at Wallingford; he had a load of white-fish carted to his factory from Branford, 16 miles distant. At night, after his men had left the factory, he cleaned out his tallow tanks, steamed his fish, and extracted the oil; his experiment was satisfactory and the process was immediately patented. The priority of his discovery is challenged by Mr. D. D. Wells, of Greenport, who claims to have used the process for some years previous to this time. After securing his patents, Mr. Hall visited numerous "pot works," which had by this time been established, for the purpose of introducing his new methods. At this time he also secured a patent for the process of drying fish scraps upon platforms by solar heat.

The inception of the oil business in Maine.

227. The first factory in Maine was built by a company from Rhode Island, in 1864, at Blue Hill, and the next by another company from Rhode Island, at Bristol, on John's Bay, the same season. Operations being successful, home parties in Booth Bay, Bristol, Bremen, and Southport went into the business. In the spring of 1866 eleven factories were built, all using steam. This may be regarded as the beginning of the industry in Maine on a scale at all in ratio with its capabilities.

Erection of factories in Maine.

228. The following table, taken from Mr. Maddock's pamphlet, gives the dates at which the factories of the several firms named were built, and the cost of the same. The titles of some have since been changed by incorporation with others, change of ownership, &c. Of the eleven factories specified before as built in 1866, one has been burned, and two absorbed by now existing corporations.

Date of building of factories in Maine.

Names.	When built.	Where.	Cost of buildings and equipment.
Gallup & Holmes	1866	Booth Bay	$15,000
Gallup, Morgan & Co	1866	do	15,000
Suffolk Oil Works	1866	do	30,000
Kenniston, Cobb & Co	1867	do	15,000
White Wine Brook Company	1867	do	12,000
Maddocks' Factory	1866	Southport (now Booth Bay)	25,000
Bristol Oil Works	1866	Bremen	10,000
Albert Gray & Co	1870	do	12,000
Round Pond Company	1866	Bristol	15,000
L. Brightman & Sons	1866	do	15,000
Pemaquid Works	1869	do	15,000
Jos. Church & Co. Works	1871	do	40,000
Loud's Island Works	1873	do	6,000
Brown's Cove Works	1874	do	10,000
Tuthill, French & Co	1868	do	10,000
Wells & Co	1864	do	12,000
Fowler, Foote & Co	1874	do	2,000
South Saint George Factory	1876	South Saint George	1,500
Total			260,500

The original investment of $260,500 has been increased, as shown by the report for 1877, to $1,033,612.

42.—THE LOCATIONS OF THE OIL FACTORIES.

Factories in Maine.

229. The oil and guano factories are located chiefly on the coasts of Maine, Rhode Island, Connecticut, and Long Island, at the localities already designated as being most frequented by large schools of menhaden.

In 1877 there were on the coast of Maine fourteen establishments of sufficient importance to be represented in the Maine Oil and Guano Association, all but two of them in good financial standing. I am indebted to Messrs. Church, Pryer and Maddocks for the detailed list given below, including those not now in operation. There are, besides, several small factories of no great statistical importance.

On Muscongus Sound, near Round Pond, are six factories owned by THE BRISTOL OIL WORKS, with two presses; ALBERT GRAY & CO., with two presses; JOSEPH CHURCH & CO., with four presses; the ROUND POND OIL COMPANY, not now in operation; LEONARD BRIGHTMAN & CO., now bankrupt; the BROWN'S COVE COMPANY (not operated in 1877), and the LOUD'S ISLAND OIL COMPANY.

On John's Bay, Liniken's Bay, and in that vicinity are ten, owned by the PEMAQUID OIL COMPANY, with three presses; WELLS & CO., with two presses; TUTHILL, FRENCH & CO., with two presses; FOWLER, FOOTE & CO.; the SUFFOLK OIL COMPANY, with two presses; GALLUP & HOLMES, with two presses; GALLUP, MORGAN & CO., with two presses; KENNISTON, COBB & CO., with two presses (not now in operation); LUTHER MADDOCKS; the WHITE WINE BROOK COMPANY.

There is also a factory at Brooklin owned by ROBERT A. FRIEND, and the SOUTH SAINT GEORGE OIL WORKS, at South Saint George.

The GEORGE W. MILES COMPANY, of Milford, Conn., have for several years operated their ship, the Alabama, with two presses, in John's Bay.

There have also been within a few years factories at Blue Hill, owned by CONARY & CO.; in Brooklin, owned by G. ALLEN & CO.; in Brookville, owned by E. C. CHATTO & CO.; in Belfast, owned by J. C. CONDON and by J. C. MAYO. The first is known to be abandoned, and no returns have been received from the others since 1873.

A considerable amount of oil is also tried out by individuals who carry on a small business of this description in connection with other occupations. The amount thus produced in 1874 was estimated by Mr. Eben B. Phillips at from 50,000 to 75,000 gallons.

Factories in Massachusetts.

230. In Massachusetts there are no important factories; the CAPE COD OIL WORKS, at Provincetown, and the NORTH AMERICAN OIL WORKS, at Wellfleet, try out a small quantity of menhaden oil annually, but this is merely incidental, their chief source of supply being bodies of stranded blackfish and porpoises.

A small quantity of oil is tried out by the fishermen on Cape Cod, chiefly, perhaps, from the refuse remaining after the fish have been "slivered" for bait.

Near Wood's Holl, Mass., is the factory of the PACIFIC GUANO COMPANY, which at the time of its establishment in 1863 was engaged largely in the fisheries and oil pressing, but has now discontinued this branch of the business. At Dartmouth is the factory of ERSKINE PIERCE, and at Fall River that of JOB T. WILSON, which is referred to below in the Narragansett Bay list.

Factories in Rhode Island.

231. In Narragansett Bay are thirteen factories, specified in the following list kindly furnished by Mr. Church:

THE ATLANTIC OIL AND GUANO COMPANY, operating 3 presses.

JOB T. WILSON & CO., at Fall River, Mass., operating 3 presses.

WM. J. BRIGHTMAN & CO., at Tiverton, R. I., operating 2 presses.

ISAAC BROWN & CO., at Tiverton, operating 2 presses, good condition.

CHARLES COOK, at Tiverton Four Corners, operating 2 presses.

AMASSA SIMMONS, at Tiverton Four Corners, operating 1 press.

ISAAC G. WHITE, at Tiverton Four Corners, operating 2 presses.

BENJ. MANCHESTER, at Tiverton Four Corners, operating 1 press.

ANTHONY MANCHESTER, at Tiverton, operating 1 press.

OTIS H. ALMY & CO., at Tiverton Four Corners, operating 1 press.

NARRAGANSETT OIL AND GUANO COMPANY, operating 2 presses.

JAMES MANCHESTER, at Tiverton, operating 1 press.

THOMAS F. GRAY, operating 2 presses.

Mr. Pryer gives the names of the following manufacturers not included in Mr. Church's list. Some of them are doubtless concerned in the titled companies already mentioned:

JOHN SOUTHWORTH, Portsmouth, R. I.

W. H. H. HOWLAND, Portsmouth, R. I.

WILCOX MANCHESTER, Tiverton Four Corners, R. I.

Rhode Island has no factories west of Narragansett Bay.

Factories in Connecticut.

232. Another group of factories is located between the eastern boundary of Connecticut and the Connecticut River. In 1877 these were five in number, as follows:

GURDON S. ALLYN & CO., on Mason's Island, between Stonington and Noank, running three gangs.

LEANDER WILCOX & CO. (formerly J. GREEN & CO.), on Mint Head, also east of Noank, running two gangs.

WALEY & CO., at Poquonnock Bridge, east of the Thames River, running one gang.

QUINNIPIAC FERTILIZER COMPANY, on Pine Island, Groton, at the mouth of the Thames River, running four gangs.

LUCE BROTHERS, at Niantic.

Several other factories were formerly operated in this vicinity, namely, the QUIAMBOG OIL COMPANY, on Noyes Neck (one gang), burnt down in 1876; the GARDNER OIL COMPANY and REUBEN CHAPMAN'S WORKS on Mason's Island (one gang), abandoned.

Luce Brothers, of Niantic, formerly had a floating factory built on the hull of the old railway ferry-boat "Union." In 1876 a new factory was built by them and the floating factory was abandoned.

West of the Connecticut River the factories are not numerous. I learn the names of the following companies:

SALT ISLAND OIL COMPANY, at Westbrook, owned by J. L. Stokes and others, not now running.

J. H. BISHOP, at Madison.

FOWLER & COLBURN, at Guilford.

E. R. KELSEY, at Branford, supplied by weir fisheries.

WELCH'S POINT OIL COMPANY, at Milford.

THE GEORGE W. MILES CO., at Milford, owning a factory on the shore and a floating factory, the "Alabama," built upon the hull of an old man-of-war. This is usually operated on the coast of Maine and is referred to in the list of Maine factories. In 1878 it is the intention of Mr. Miles to work it on the coast of New Jersey.

Factories in New York.

233. At the eastern end of Long Island is another cluster of oil works. The following list was furnished by Capt. Benjamin H. Sisson in 1873:

D. D. WELLS AND SONS.

HAWKINS BROTHERS.

H. CORWIN & CO.

FITHIAN & HORTON.

BENJAMIN PAYNE, GREEN & CO.

B. C. CARTWRIGHT & CO.

VAIL, BENJAMIN & CO.

THE STERLING CO.

Also two floating factories the "Falcon," 2,500 tons, Capt. Geo. F. Tuthill; the "Ranger," 1,500 tons, Capt. F. Frank Price.

Many have since been established and in Mr. Pryers' list (Appendix H) the following manufacturing firms are enumerated, fifteen in number:

W. Y. FITHIAN & CO., at Napeague (Amagansett).

GREEN BROTHERS, at Amagansett.

JOSEPH D. PARSONS, at Springs.

G. H. PAYNE, at Deep Hole, Easthampton.

HAWKINS BROTHERS, at Shelter Island.

B. C. CARTWRIGHT, at Shelter Island.

HENRY E. WELLS, at Greenport.

GEORGE F. TUTHILL, at Greenport.

T. F. PRICE, at Greenport.
J. NORRISON RAYNOR, at Greenport.
W. H. H. GLOVER, at Southold.
G. H. CLARK, at East Marion.
W. W. WARNER, at Good Ground.
W. C. RAYNOR, at Westhampton.
NELSON BURNETT, at Southampton.

On the Great South Bay are four factories:

J. S. HAVENS, at Patchogue.
SMITH, GREEN & CO., at Sayville.
SMITH & YARRINGTON, at Sayville.
SOUTH BAY OIL COMPANY, at Sayville.

On the south shore of Long Island, at Barren Island, a few miles east of the entrance to New York Harbor, at the mouth of Jamaica Bay, are four factories, owned by—

SEAMAN JONES & CO.
HAWKINS BROTHERS.
FRANK SWIFT.*
BARREN ISLAND MANUFACTURING COMPANY.

In these four factories, according to Mr. Seaman Jones, about $200,000 capital is invested, half of it on shore and half in "sailing rigs."

Factories in New Jersey.

234. In 1873 there were said to be one or two oil factories in Southern New Jersey, at Somers Point and Little and Great Egg Harbors. The fisheries in this vicinity are not vigorously prosecuted, and in 1873 the factory at Atlantic City had already been deserted. Mr. Miles informs me that he proposes to operate his floating factory, the Alabama, in New Jersey waters during the coming season of 1878.

According to Mr. Pryer the following factories were in existence in 1877:

GRIFFIN & VAIL, at Port Monmouth.
CAPT. C. DOUGHTY, at Somers Point.
MORRIS & FIFIELD, at Somers Point.
JAMES E. OTIS, at Tuckerton.
CYRUS N. SMITH, at Tuckerton.

Factories on Chesapeake Bay.

235. I am informed by Mr. H. L. Dudley that there are four factories in the Chesapeake Bay between Norfolk and Baltimore. I have not learned the names and locations of all these establishments. One, "THE VIRGINIA OIL AND GUANO COMPANY," of which Mr. O. E. Maltby, of Norfolk, is president and Mr. Dudley agent, is located at New Point Comfort. A second is owned by WILLIAM D. HALL, of Willenbeck,

* Better known by the name of its former owner, Mr. Koon.

Lancaster County, Va., who was formerly connected with the Quinnipiac Fertilizer Company. A third was the MANOKIN OIL WORKS, owned in 1873 by CROCKETT & Co., and a fourth on Tangier Island, owned in 1873 by FORD, AVERY & CO. The Manokin Works are said to be in Pocomoke Bay. A factory was operated near Norfolk in 1872 by Mr. Fitzgerald, but this has since been destroyed by fire.

F. H. HARKER has a factory at Hampton, Va.

Factories on the southern coast.

236. South of Cape Henry there are no factories now in operation. Mr. W. F. Hatch, keeper of Body's Island light, North Carolina, gave the names of the following factories in that vicinity which had at that time already been abandoned:

EXCELSIOR WORKS (cost $30,000).

CHURCH & Co. (cost $5,000).

ADAMS & Co. (cost $5,000).

There is still another abandoned factory near Beaufort, N. C.

At Charleston, S. C., are the works of the Pacific Guano Company, which consumes immense quantities of menhaden scrap. This is however brought from the water by the vessels which carry on their return trip a supply of South Carolina phosphates for the other factory owned by the company, at Wood's Holl, Mass.

A company in Charleston has a charter for establishing a menhaden fishery at the mouth of Charleston Harbor.—(*C. C. Leslie.*)

43.—METHODS OF OIL MANUFACTURE.

The principles involved.

237. The manufacture of menhaden oil is simple in the extreme, consisting of three processes: boiling the fish, pressing, and clarifying the expressed oil. The apparatus absolutely needful is correspondingly free from complication, consisting, for the first process, of a cooking vessel; for the second, a press, and for the third a shallow vat or tank. These were used twenty-five years ago by Mrs. Bartlett, the manufacturer of the first menhaden oil, who produced an article little inferior to the best now in the market. Very few patents for improved methods of manufacture have been granted: Mr. W. D. Hall's patent for steam-rendering is the most important. The principal changes have been in the introduction of labor-saving appliances, which enable manufacturers to carry on their business with the smallest possible force of workmen. Steam is of course an important auxiliary in handling the fish and in working the presses, and is also used to great advantage in heating the cooking-tanks, as well as for pumping the water and oil. The hydraulic press has replaced the old fashioned screw-press in most of the larger establishments, and the size, shape, and arrangement of the bleaching vats, as well as the methods of drawing and pumping the oil from one to the other, have been perfected.

Processes employed in manufacture.

238. The process of oil-making at the larger works is essentially as follows: The fish are conveyed to the upper story of the factory on wooden tramways in cars containing about twenty barrels each, and are dumped into large reservoirs from which the cooking-tanks are replenished from time to time, or are emptied directly into the cooking-tanks, which are filled to the depth of six inches with sea-water. From fifty to seventy-five barrels are placed in each cooking-tank, and then steam is turned on and they are boiled for half an hour or more. In this way about two-thirds of the oil is separated; the remainder is expressed by means of the hydraulic presses, under a pressure of 50 to 150 tons or less; the fish having been placed in circular curbs of half-inch iron, perforated with holes an eighth of an inch in diameter, each curb having a capacity of three to ten barrels. The oil mixed with water is now run into the "drawing-off tanks" while it is still hot, and is passed through several of them, the water separating and sinking to the bottom. The oil is now drawn off into a "settling-tank" of four or five thousand gallons capacity, where it remains a few hours to allow impurities to sink to the bottom. Finally, it is pumped into "bleaching-tanks" (of which Judson, Tarr & Co. have five, each containing four thousand gallons), where it becomes clearer and whiter in the rays of the sun, and after one or two weeks' exposure is ready for shipment.

Processes employed in refining.

239. Boardman & Atkins make the following statements about processes of refining:

"The oil and water running together into the receivers, separate, by the oil rising to the top, whence it can be drawn or skimmed off. Great pains must be taken to separate the oil from the water before the impurities contained in the latter begin to ferment, for if this happens the quality of the oil suffers much. Moreover, in what appears at first to be pure oil there is a variable amount of finely divided fleshy substance that must be allowed to settle, as it will after a while, and the clarified oil drawn off before putrefaction sets in. In order to effect the separation, the oil is commonly passed through a number of settling-vats, and a portion of the impurities deposited in each, and finally before barreling, the oil is, if practicable, exposed some hours to the sunlight in a broad, shallow tank. If all these processes are successfully carried through, the oil is light-colored, sweet, and of prime quality; but if it is exposed at any time to the influence of putrefying animal matter, it becomes dark and 'strong.' The very strongest of oil is made from the 'gurry' or settlings of the oil, after fermentation, by steaming or boiling it over.

"It naturally happens that every manufacturer makes several grades of oil, of very different quality, of which the best is very sweet, fine oil, bringing ten cents a gallon more than a strong article. Notwithstand-

ing this fact, it is said to be the common practice of dealers to pour all grades into the same vat, and this has led manufacturers to take less pains to keep them separate.

"It is a curious fact that oil made from early fish is not so good as that made later. It is called 'weak,' and brings in market five cents per gallon less." *

Gurry oil is sold for one-third less than the other grades.

Perhaps the most satisfactory way of indicating the processes now in use will be to describe three or four of the principal factories in detail.

The factory of The George W. Miles Company.

240. The factory of The George W. Miles Company at Milford, Conn., illustrated in Plate XXV, is said to have been the first one built after the model now universally followed, with the cooking-tanks and oil-presses upon the second floor of the building.

When the fishing fleet comes in, the fish are hoisted from the holds of the vessels into cars, in which they are carried over an inclined tramway to the upper story of the factory building. Here they are turned into tanks, twenty thousand fish in each, and cooked by steam-power. Then the water is drawn off and the cooked fish are placed in perforated iron curbs, which are so arranged upon railways that they can be pushed under a hydraulic press. Each curb-load of fish is subjected to a pressure of sixty or seventy tons, by which the greater part of the oil is extracted. The scrap is then dropped into the cellar below.

The ship "Alabama" is owned by the same firm. It is used as an oil factory, and is usually more productive than the stationary works owned by the same firm. It is illustrated in Plate XXX. For several seasons it has been taken to Maine during the fishing season, where it is usually stationed near South Bristol. It is the intention of the owners to take it to the coast of New Jersey for the season of 1878.

The factory of Judson Tarr & Co.

241. Messrs. Judson Tarr & Co., of Rockport, Mass., kindly furnished the following account of their factory in Pemaquid (Bristol), Me., as it was in 1873:

"The size of the main factory is 30 by 40 feet, with 16-foot posts; the building is two stories high, the upper story being used for cooking and pressing the fish, the lower as an oil-room and for storing fish-scrap. The engine-house adjoining the factory measures 20 feet by 30, with 10 foot posts, and contains three horizontal boilers each of sixty-five horse power. In the upper story of the factory are eleven round wooden cooking-tanks 12 feet in diameter and 4 feet deep; each tank has steam-pipes in its bottom, perforated with small holes to allow the escape of the steam; there are also three hydraulic presses, each with pressure of one hundred and fifty tons, and a small engine of ten-horse power.

* Op. Cit., p. 27.

Connected with the factory are two wharves, the longer 150 by 50 feet in dimensions, the shorter 40 by 80. At the end of the long wharf is placed, on posts 10 feet high, a tank capable of containing 4,000 barrels of menhaden. This tank is sometimes completely filled when all the steamers have discharged their loads after a successful day's fishing. On the wharf is an engine of twelve-horse power connected with three drums, all or either of which may be used; when in full blast one thousand barrels can be transferred from the steamers to the tank in an hour, the process being precisely similar to that of unloading coal from barges.

Also, on the premises of the company, are a main scrap-house, 100 feet by 60, with 15-foot posts, and blacksmith's, cooper's, and carpenter's shops, as well as a boarding-house and stable, all used in connection with the business.

The amount invested in buildings and machinery is between $75,000 and $80,000, and in steamers and fishing gear, such as seines, small boats, &c., is about $60,000 additional.

The utmost capacity of the factory is 2,000 barrels per diem. About thirty-five men are employed at the factory.

The factory of Joseph Church & Co.

242. The Muscongus Oil Works, on Muscongus Point, Maine, the largest in the United States, were visited by Professor Baird in September, 1873. These works were erected in 1872, and are carried on by Joseph Church & Co., of Tiverton, R. I.* The main building is 161 feet long and 40 feet wide. The lower portion is the receptacle of the chum, where about 1,800 tons were in store on the 25th of September, three cargoes of about 190 tons each having been sent away during the year. The establishment is larger than any other in the United States, and is well appointed in every particular, capable of working up more than 3,000 barrels of fish in a day. About forty-five men were employed at these works, and about 5,500 tierces of 40 gallons of oil each had been manufactured during the year. These works are now much more extensive, employing during the past season (1874) seventy fishermen and seventy factory hands, with four steamers and three sailing-vessels. They have invested in buildings and machinery $65,000, and in fishing gear $55,000. During the season 138,000 barrels or about thirty-four millions of menhaden were caught; 200 barrels were sold for bait, and of the remaining 136,000 barrels they manufactured 450,000 gallons (11,250 tierces) of oil and 4,000 tons of chum or guano.

The factory of Kenniston, Cobb & Co.

243. The establishment of Kenniston, Cobb & Co. is selected for description by Boardman and Atkins, who state that though not one of the largest, it is generally conceded to be a model of convenience and efficiency.

---

* Illustrated in Plate XXIX.

"The main floor of the factory stands a considerable height above the water. Here are all the steam tanks and the press, and in an adjoining building is the boiler and the principal engine. The tanks are of wood, 8 feet square and 4 feet deep, with a capacity of fifty-one barrels, with a board platform on which the fish rest, 4 inches above the bottom. Into the space between the platform and the bottom the steam is introduced. There are tanks arranged in two rows, between which runs the track leading from the landing. Another track passes by all the tanks and leads to the press. On this track run several cylindrical curbs made of wood and iron. The press is hydraulic, and is worked by steam. On a lower level than the steam tanks are series of receptacles for the oil and water, that are brought to them by conductors leading from the tanks and press. Under the main floor is the scrap-house, into which the scrap is dumped through a scuttle in the floor. The track that runs between the rows of tanks leads down a steep incline to the landing, where there is another engine, and an elevator to take the fish out of the boats. The elevator delivers the fish into a hopper that holds fifty barrels, and from this they are drawn into a car that holds seventeen barrels, so that the unloading of the boat may go on without intermission while the car is carrying its load up to the tanks. The car is drawn up by the engine on the landing, and dumps its load into either of the tanks at pleasure.

"Preparation for the fish is made by filling the tank a foot deep with water and steaming it until hot. The fish are at first steamed hard from forty to sixty minutes, then punched and broken up. After simmering for five hours longer the free water and oil are drawn off, and then, if possible, the broken fish stand draining and cooling for several hours. At last they are pitched into the curbs, run under the press, and subjected to a pressure which is gradually brought up to seventy-five tons. This wrings out all the water and oil that it is practicable to extract, and the cheese is now dropped into the scrap-house to remain until the following autumn or winter."*

The factory at Napeague, N. Y.

244. In the American Agriculturist for December, 1868, p. 452, was published a description of the factory at the entrance to Napeague Harbor, near Montauk Point. In Plates XXVI and XXVII are reproduced the illustrations of the factory and its interior arrangements. The following description of the factory was published at the same time:

"The fish are taken to the factory's dock. At the factory the fish are measured either in cars or boxes, and are drawn upon the railway to the tanks, where they are thrown into water, and a full head of steam turned on into the bottom of the tank, which contains some sixteen to eighteen thousand fish. After thirty minutes' cooking, the water is drained off, and a man getting into the tank fills the curbs, which are circular, and

* Op. cit., p. 27.

formed of strong wooden slats, bound and lined with heavy iron. These are rolled under a solid, stationary head, fitting closely the inside of the curb, and against which the fish are pressed, as the curb is slowly but powerfully raised by a hydraulic press. The oil and the water absorbed by the fish in boiling are pressed out through the slats and carried by leaders to the tanks in the shed by the side of the factory, where the oil-man skims, boils, and otherwise prepares it for barreling. As soon as the pressure is taken off, the curb slowly resumes its position on the railway, and is pushed to where a man stands ready to remove the cheese as it falls from the curb, upon the opening of its hinged bottom. This cheese or scrap-cake is ground to different degrees of fineness, to form the fish guano. This substance, being rich in ammonia-producing material, is used by some manufacturers of fertilizers to supply ammonia to phosphates that are deficient in that constituent."

The model of a factory in the National Museum.

245. A complete model of the oil-factory of Joseph Church & Co., at Round Pond, Me., was exhibited in the Department of Fisheries in the United States Government building at the Philadelphia Exhibition. It is now deposited in the United States National Museum.

The cost of an oil-factory.

246. The larger part of the cost of an oil factory consists in the machinery, as the buildings are always of wood, substantial but cheap. The amount invested in factories by different manufacturers appears to range from $2,000 to $65,000. The average amount invested in the fourteen factories of the Maine Association is $22,600, but the general average will not probably exceed $12,000 or $15,000.

Mr. Church, of Tiverton, R. I., speaking of the establishments on Narragansett Bay, remarks that a factory ready for business, including buildings, tanks, boilers, hydraulic presses, oil-room, &c., of a capacity to cook and press 800 barrels (200,000) in a day, costs not far from $14,000. A hydraulic press costs about $1,200; in 1877, $700.

Mr. Miles, of Milford, Conn., states that boilers cost from $2,000 to $4,000, hydraulic presses with curbs and fixtures $2,000; engines, pumps, shafting, and pulleys, together with the necessary buildings, bring the cost of the factory to from $10,000 to $50,000.

Capt. B. H. Sisson, of Greenport, N. Y., estimates the cost of boilers, engine, piping, hydraulic press worked by steam, steam drying machines, and steam hoisting apparatus, to cost from $10,000 to $25,000 for each factory.

Mr. Dudley states that a factory running three or four gangs of fishermen costs from $20,000 to $30,000.

The capital invested in the factory is one-half of the whole amount. The fourteen establishments of the Maine Association had in 1874 $316,000 in buildings and machinery and $390,000 in "gear"; that is,

in steamers, sailing-vessels, small boats, and nets; an average of $27,800 to each for gear against $22,600 for factory.

In Connecticut, according to Mr. Dudley, about the same proportion holds.

The total amount of capital invested in the several companies is given, by Mr. Jasper Pryer, as follows:

G. S. Allyn & Co	$25,000 00
Wm. J. Brightman & Co	20,000 00
J. H. Bishop	9,000 00
Bristol Oil Works	35,000 00
Brown's Cove Company	23,000 00
Isaac Brown & Co	9,000 00
Barren Island Manufacturing Company	17,500 00
Joseph Church & Co. (Rhode Island)	17,000 00
Do (Maine)	200,000 00
Charles Cook	18,000 00
G. H. Clark	500 00
Fowler, Foot & Co	42,000 00
Fowler & Colburn	47,000 00
W. Y. Fithian & Co	20,000 00
Robert A. Friend	5,500 00
Albert Gray & Co	55,000 00
Gallup & Holmes	70,000 00
Gallup, Morgan & Co	44,000 00
W. H. H. Howland	20,000 00
S. Jones & Co	30,000 00
Kenniston, Cobb & Co	25,000 00
E. R. Kelsey	8,000 00
Loud's Island Oil Company	25,000 00
Luce Bros.	50,000 00
Maddocks Oil Works	130,000 00
The George W. Miles Company (Maine)	59,000 00
Do (Connecticut)	45,000 00
Morris & Fifield	5,000 00
James Manchester	3,000 00
James E. Otis	11,000 00
Erskine Pierce	11,000 00
Quinnepiac Fertilizer Company	110,000 00
Round Pond Oil Works	42,000 00
Suffolk Oil Company	45,000 00
South Saint George Oil Works	37,000 00
Smith & Yarrington	15,000 00
Tuthill, French & Co	21,000 00
Griffin & Vail	10,000 00
Job F. Wilson	40,000 00

Waley & Co	$15,000 00
Isaac G. White	35,000 00
Wells & Co	60,000 00
Leander Wilcox & Co	30,000 00
Cyrus W. Smith	7,000 00
Westbrook Oil Company	1,000 00
Eleven factories in Gardiner's Bay, N. Y	310,000 00

The total amount here specified is $1,857,500. It should be noted that several companies are not reported.

Organization of the fishing gangs.

247. "In the early days of the business," says Mr. Dudley, "the manufacturers did not own the fishing-vessels, nor were they interested pecuniarily in the fishery; they bought the fish from independent fishermen. This method was found unsatisfactory; the fishermen sold to the highest bidder, and the supply was uncertain. Of late years the company owns the vessels which supply it with fish. The crew work upon shares, as in other fisheries. In the settlement, at the end of the season, a sailing-vessel, with seine and gear, draws one-third of the net proceeds; a steamer, one-half; the remainder is divided by the crew, the captain receiving an ordinary share, in addition to which he is paid a salary by the company, either fixed or proportionate to the success of the season's work. It is not uncommon for a successful captain to receive a "bonus" of $500, or sometimes $1,000. In settling the season's account, the total catch is paid for at a rate proportionate to the yield of oil. In 1876, the Quinnipiac Fertilizer Company paid $1.25 per thousand. The company usually advances pay to the men to the extent of $1 a thousand, and at the end of the season a final settlement is made. The crew of a sailing-vessel will average form $35 to $75 a month; the crew of a steamer somewhat more."

Advantages claimed for floating factories.

248. Floating factories are in use chiefly on Long Island Sound; in whose protected waters they operate to great advantage. They are now going out of use on account of the introduction of steamers. They are usually built upon the hull of some old vessel, and are towed from point to point, gathering the fish from the smacks and working them up into oil and guano as they move. Some of them are fitted up with machinery for very extensive manufacture. Two important objects are attained by the owners of floating factories: the objection to their business arising from the offensive odor is to a considerable extent removed; by following the movements of the fish time and expense are saved, for by bringing the factory to the fish they obviate the necessity of having a fleet of lighters to carry the fish to the factory, which might often require two or three days. There are five of these factories; one owned at Milford, Conn., and four at Greenport, N. Y.

Mr. Goodale's improved method.

249. I quote from Mr. Maddocks's excellent little report the following account of an improved process devised by Mr. Goodale:

"As now generally managed, the scrap remains in large heaps until shipped, in autumn or winter, to the points of manufacture into, or incorporation with, superphosphate. In this time a portion of the oil and water leaks away, so as to leave about 10 to 15 per cent. of the former, and 48 to 53 per cent. of the latter. The elimination of the water is an advantage, but the specified per cent. of oil is lost; and a portion of nitrogen is also lost, resulting from the partial decomposition of the mass, the formation and escape of ammonia. It were better, if practicable, to drive off the water at once upon withdrawal from the press, so as to prevent the loss in question.

"What has hitherto prevented the driving off of the water immediately by artificial heat has been the presence of so much *oil*, together with the gelatinous or gluey matter which is developed during the cooking, chiefly from the skins and bones. These render the process of drying the scrap a very difficult and tedious one, so much so that comparatively little has been put into market in that desirable form. The recent discovery of an easy and simple process for removing the larger part of the oil, and also at the same time the gelatinous hinderance to drying, gives promise of a speedy change in this respect.

"While pursuing investigations relative to utilizing the menhaden as a source of concentrated food, before referred to, Mr. S. L. Goodale, well known as a chemist as well as for his eminent services to the State as secretary of the board of agriculture, found, by thoroughly washing the scrap as it came from the press, with sufficient hot water and agitation, that the oil globules were liberated from their entanglements in the fleshy tissues, and also from the creamy mixture with the gluey matter into which they were forced by the pressing, so that the greater part of it could be readily recovered by draining and re-pressing; and also that after such washing the scrap would bear heavier pressure than at first without 'squirting.' By this easy process the oil product is largely increased, the scrap is left free from the gluey hinderance to drying, and contains less water to be dried out.

"It may appear strange that so simple a method should not have been discovered sooner, but such is the fact. Work had been done on both sides of it. Re-pressing had been tried, using extra strong curbs, with very powerful pressure, but it failed to give satisfactory results. Re-cooking had been resorted to, which resulted in injury to the oil, and in the development of an additional amount of the gelatinous matter. It is now seen that a simple thorough washing in hot water accomplishes the desired end with neither of these objectionable results. Scrap made by this process last August (1877), and dried in the open air, was lately analyzed at the agricultural experiment station of Connecticut, and the statement of the director, Prof. S. W. Johnson, of New Haven, shows

the proportion of moisture to be reduced to 11.45 per cent., or about one-fifth that contained in the scrap fresh from the press, and the proportion of *oil* to 4.65 per cent., thus proving that the content of oil in the *washed scrap as it came from the press* (before drying it) had been reduced to less than 2½ per cent. According to these figures, the proportion of oil hitherto lost is, by the new process, reduced from an average of, say, 15 per cent. of the weight of the scrap as it commonly issues from the press, to about 2 per cent.; the balance, say, 12 or 13 per cent., is saved. Let it be assumed, however, that only 10 per cent. can be realized in practice, and that the annual outturn of scrap from the factories of the Maine Association is only 40,000,000 pounds. This would give an annual saving of 4,000,000 pounds of oil, or 533,000 gallons, worth at current prices at market for 1877, 40 cents per gallon, $213,200."

Proposed chemical methods.

250. Other methods of extracting the oil from fish scrap have been proposed, but their adaptability is not yet so certainly proved as to warrant their adoption by manufacturers.

The proposed plans involve the use of the fumes of benzine, or bisulphide of carbon, which are brought into contact with the fish in air-tight chambers. The oil is absorbed by these substances, and collects in tanks in the floors of the chambers. Any surplus of benzine or bisulphide of carbon which may remain in the oil is expelled by distillation.

The *naphtha* process for extracting the oil, remarks Mr. Maddocks, consists in subjecting the scrap, in an inclined iron cylinder, to the action of vapors of naphtha, which combine with the oil, and the latter in a state of solution filters away at the lower end of the cylinder. The naphtha is then recovered by evaporation. The process is slow, costly, and dangerous.

Proposed mechanical methods.

251. It has been suggested that a recently invented filter-press, the invention of Mr. John Bowing, is well adapted for the extraction of oil from the menhaden and the formation of the residue into cakes. It is probably too small for the extended operations of manufacturers, but may be very serviceable for the use of refiners. Mr. C. B. Norton, 25 Astor House, N. Y., is the American agent.

44.—Value of fish for manufacturing purposes.

Prices of fish at different seasons.

252. The price of fresh menhaden cannot be definitely stated, since it varies from week to week with the abundance and fatness of the fish and the needs of individual manufacturers.

Many factories rely entirely upon their own "gangs" for their supplies; some others buy the fish of the vessels engaged in the trade,

though this practice is less common than it formerly was. Still every factory buys fish in greater or less quantity, and the answers to question 47 of the circular are important in exhibiting the variations in abundance at different points on the coast. Perhaps it may not be amiss to quote fully from the letters, it being quite impossible to tabulate the facts.

Mr. William H. Sargent, of Castine, Me., says: "For four years past the average price has been 65 cents per round barrel.*

Jason Luce & Co., of Menemsha Bight, estimate that menhaden average from 225 to 240 in a barrel.†

In the report of the committee on statistics from the United States Association for the meeting of 1875, the estimate was put at three barrels to the thousand fish, or 333 fish to the barrel.

Captain Tuthill estimates 22 cubic inches to each fish, Captain Sisson 21, making three and one-half barrels to the thousand. In Long Island Sound the fish are sold by the thousand; farther east, always by the barrel.

Mr. Condon, of Belfast, estimates the price for 1873 at 60 cents; Mr. G. B. Kenniston, of Booth Bay, at 75 cents, stating that in previous years the price has ranged from 50 cents to $1.25. Mr. B. F. Brightman says that in 1872 and 1873 the average has been 65 cents, but that when oil was high they have brought $1. Mr. J. Washburn, of Portland, estimates the price at $1 for 1873; during the war, much higher. Mr. Eben B. Phillips estimates the price at from 60 to 70 cents in 1873, 56 in 1874, and about 60 in previous years. Fall fish, for trying, bring 40 to 50 cents in Wellfleet, Mass., according to Mr. Dill. At Nantucket, according to Mr. Reuben C. Kenny, the fish are worth from 50 to 75 cents as taken from the nets; only about half are used in the manufacture of oil.

Mr. Church gives the average price on Narragansett Bay at 40 cents, and to this correspond very nearly the estimates of the southern shore of Cape Cod and the Vineyard Sound, which find market for their menhaden at the Narragansett factories.

Captain Crandall, of Watch Hill, R. I., thinks $2 to the thousand a fair estimate for 1873 and 1874. Captain Beebe, of Niantic, Conn., agrees with this, giving $2.50 for previous years. Mr. R. E. Ingham, of Saybrook, says $1.25 to $2. Mr. Miles says that in 1873 the prices ranged from $1 to $2.50, according to the yield of oil. Mr. F. Lillington, of Shatford, puts it, for 1875, at from $1.50 to $2. Captain Sisson, of Greenport, says that in 1873 the price was $2.25; in previous years, $1.75; in 1874 the price was lower. Collector Havens, of Sag Harbor,

* A "round barrel" is a barrel of undressed fish, and weighs about 200 pounds. The number of fish in a barrel necessarily varies with their size. Estimates range from 180 to 280; but that made by Mr. Fairchild, at the meeting of the "United States Menhaden Oil and Guano Association," in 1874, is perhaps fair, putting four barrels to a thousand fish, or 250 fish to a barrel.

† Report United States Commission Fish and Fisheries, 1871–'72, p. 35.

N. Y., estimates it at 30 cents per barrel. In the vicinity of Atlantic City, N. J., M. A. G. Wolf gives the price at $1.25 to the thousand; and Mr. Albert Morris, of Somers Point, at 39 cents per barrel (about $1.50 to the thousand). Mr. Hance Lawson, of Cresfield, Md., states that the Chesapeake factories pay 15 cents per bushel.* Mr. Dudley says that in 1877 the average price in the Chesapeake was 50 cents a thousand.

Prices proportionate to amount of oil contained in fish.

253. These prices are simply those paid for fish used in the manufacture of oil and guano, the prices of those sold for bait or food being given under other heads. No satisfactory conclusions can be drawn from these statements, except the very general one that the fish are more valuable on the eastern than on the southern coast of New England; in Maine bringing from $2.40 to $3.20 to the thousand; on Long Island Sound, $1 to $2.25. As the expense of capture is necessarily as great in Southern as in Northern waters, we must seek the reason of the difference in price either in the methods of manufacture, the abundance of the fish, or in the intrinsic value of the fish for the purposes of the manufacturer.

Oil yield of Northern fish.

254. On the first arrival of the schools in Northern water the fish are thin and do not yield a large quantity of oil; but they rapidly gain until the time of their departure in fall, so that the late fishing is by far the most profitable. It is the general opinion of fishermen that Northern fish yield a larger proportionate amount of oil than Southern.

Mr. Sargent, of Castine, Me., says that three quarts of oil to the barrel is the smallest yield he has ever known from the first school, and six gallons the most from the last school. When the fish are very poor, about the 1st of June, it takes 250 to make one gallon of oil; when poor, in July, 200; when fat, in August, 150; when very fat, in October, 100. About one ton of scrap is obtained in making three barrels of oil. Mr. Condon states that when the fish arrive in the spring they will produce but one gallon to the barrel, while in October the yield is four or five gallons; the average for the season being three gallons. Mr. Friend states that the least yield, in June, is two quarts to the barrel; the greatest, in August, four gallons. Mr. Kenniston states that May fish yield three pints to the barrel; October fish, six gallons and one-half. These are no doubt intended as the extreme figures. The average yield is two and one-half gallons to the barrel, an estimate in which Mr. Brightman concurs, though placing the lowest at three quarts; the highest, in August and September, at four gallons. He estimates the yield of a ton of scrap at thirty to forty gallons, according to the season. Judson Tarr & Co. put the early fish at less than a gallon, the September fish at four gallons to the barrel. Mr. Babson thinks that the early

* About 50 cents per barrel, or $2 to the thousand.

fish yield about a gallon, the last four gallons; an estimate in which he is confirmed by Mr. E. B. Phillips.

Mr. Erskine Pierce, of Dartmouth, Mass., states that in 1877 the average yield at his factory was $1\frac{1}{4}$ gallons to the barrel.

According to Mr. Church, the fish are fattest generally in the fall, though after a warm winter he has known them after first arrival to yield $2\frac{1}{2}$ gallons. After a cold winter the opposite is true; and he has seen them so poor in the summer that out of one hundred barrels of fish not a pint of oil could be extracted. The first 18,000 barrels taken by Church & Co., on the coast of Maine, in 1873, did not make over 11,000 gallons of oil (about three quarts to the barrel). On Narragansett Bay, in 1873, the yield was $1\frac{1}{2}$ gallons less than on the coast of Maine; on Long Island Sound, half a gallon.

Mr. Reuben Chapman informed me that at his factory, on Mason's Island, opposite Noank, Conn., the yield of early fish was sometimes as low as a gallon to the thousand, later in the season reaching fourteen or even eighteen gallons; which would be equivalent to five or six gallons to the barrel.

Mr. Maddocks, writing of the Maine fish, states: "The yield of oil sometimes doubles, per head, in thirty days after their coming. The fish taken on the coast of Maine yield a considerably larger supply of oil than those taken at points farther south, around Long Island, off the Jersey shore, &c. The amount of oil per barrel of fish is there about one gallon, against two and a half here, for the whole season in each case."

And again: "The amount of oil realized varies from one gallon per barrel of fish early in the season to four or five gallons in September. The scrap contains, on the average, as it comes from the press, 55 to 60 per cent. of its weight in water, and sometimes more. This is, of course, worthless for fertilizing purposes. It also contains from 12 to 20 per cent. of fat or oil, which is equally worthless for manure."

Mr. Dudley considers that the first taken in Long Island Sound yield, on an average, about 4 gallons to the thousand. At Pine Island it is somewhat greater; one season averaged $3\frac{1}{2}$, another $6\frac{1}{2}$. In 1877 the average to June 12 was 5 gallons; to November 1, 3 gallons. On November 1 the fat fish made their appearance, and the average has since doubtless greatly increased. There is usually an increase in the yield of oil after July 1, but since 1874 this has not been the case in Southern New England. Mr. Dudley has cooked fish which would not yield a quart of oil to the thousand. Again, in November, the yield has been 18 gallons. It is the opinion of Mr. Dudley that dark oil only is yielded by fish taken in brackish water; light oil by those taken outside.

The George W. Miles Company, of Milford, states that the largest amount made by them in one factory in any one year was in 1871, when they produced 100,000 in about fifty working days; the largest quantity in the shortest time was 21,000 gallons in seventy-two hours, or 7,000

gallons to each day of twenty-four hours. In 1872 they produced 60,000 gallons, and in 1873 105,000 gallons in their two factories, one factory not operating all the time on account of a pending lawsuit.

According to Capt. J. L. Stokes of the Salt Island Oil Company, the average yield of oil is four gallons to the thousand, 9,000 fish making a ton of scrap. Captain Beebe and Mr. Ingham put the highest for the region about the mouth of the Connecticut River at eight gallons, or perhaps three gallons or less to the barrel.

Mr. Miles writes: "All depends upon the quality of the fish, whether fat or poor. In July, August, and September we only get fish that come into the Sound to feed, and they fatten after they get here. If they are poor, we have the largest catch in June and July; if they are increasing in fat or yield of oil, we cannot capture them successfully until August and September. The fat fish in the Sound are usually wild and hard to take until late, perhaps owing to the fact that their food is plenty and low in the water. When the season is unusually dry, the fish are sure to be fat; but in a wet season they are found to be below the average in yield of oil. After the fish get here, if their food is plenty, they grow fat very fast. In the past season (1873), in May and June, one million of fish would make only 800 gallons; in August, the yield was from 8 to 10 gallons per thousand, and in September, 10 to 12."

At Greenport, in 1873, the average yield, on Captain Sisson's estimate, was $8\frac{1}{2}$ gallons to the thousand; the smallest yield, half a gallon in spring and late fall; the greatest, 22, in September and October; 8,000 fish make a ton of green scrap. Mr. Havens puts the lowest yield at one quart to the barrel, the highest at 4 gallons, an estimate much below Captain Sisson's, which would make over 6 gallons to the barrel.

Hawkins Bros. estimate the lowest yield at one gallon to the barrel in midsummer, and $4\frac{1}{2}$ in October and November, putting the average quantity of fish to the gallon at one-third of a barrel on Gardiner's Bay, one-half at Barren Island, and 85 gallons to a ton of scrap on Gardiner's Bay, 57 at the island.

At Atlantic City, N. J., according to Mr. A. G. Wolf, the average yield is 4 gallons to the thousand, the greatest in November, 11; a ton of scrap corresponding to 40 gallons of oil.

On Great Egg Harbor, states Mr. Morris, July fish yield one quart of oil to the barrel; those of October and November yielding 4 gallons. A gallon of oil is the average to each barrel of fish, and 45 gallons to a ton of scrap.

The yield to each barrel of fish was thus estimated by Rhode Island manufacturers in 1877: Joseph Church & Co. and W. H. H. Howland, 1 gallon; Charles Cook, Job T. Wilson, Isaac G. White, and James Manchester, $1\frac{1}{4}$ gallons; Isaac Brown & Co., $1\frac{1}{39}$; and William J. Brightman, $1\frac{1}{3}$.

Connecticut manufacturers are estimated as follows: The George W. Miles Company, $2\frac{3}{4}$ gallons to the thousand; Leander Wilcox & Co., 3

gallons; G. S. Allyn & Co., $3\frac{1}{8}$ gallons; Waley & Co. and Luce Brothers, $3\frac{1}{4}$ gallons; the Quinnipiac Fertilizer Company, $3\frac{1}{3}$ gallons; J. H. Bishop, $3\frac{1}{2}$ gallons; and Fowler & Colburn, $3\frac{3}{4}$ gallons.

New York manufacturers are estimated as follows: The Barren Island Manufacturing Company, G. H. Clark, W. Y. Fithian & Co., $2\frac{1}{2}$ gallons to the thousand; Smith & Yarington, $2\frac{3}{4}$ gallons; S. Jones & Co., $4\frac{1}{2}$ gallons; eleven factories in Gardiner's Bay, 3 gallons.

New Jersey manufacturers are estimated as follows: Morris & Fifield, 2 gallons to the thousand; James E. Otis, Griffen & Vail, Cyrus H. Smith, $2\frac{1}{2}$ gallons.

Maine manufacturers in 1877 were reported as follows: Albert Gray & Co., $1\frac{1}{2}$ gallons to the barrel; Gallup, Morgan & Co., $2\frac{9}{594}$ gallons; Fowler, Foot & Co., $2\frac{1}{6}$ gallons; Suffolk Oil Company, $2\frac{1}{4}$ gallons; R. A. Friend, $2\frac{1}{2}$ gallons; Gallup & Holmes, $2\frac{1}{3}$ gallons; Loud's Island Company, $2\frac{3}{4}$ gallons.

M. Maddocks declares that on the coast of Maine "one hundred and ninety-five pounds of fish make a barrel. One barrel yields about two and a half gallons of oil or eighteen and three-quarter pounds. One barrel yields about eighty pounds of chum or scrap."

Oil yield of Southern fish.

255. Mr. Kenniston makes the following statement: "Corresponding with the successive appearance of the menhaden from South to North there is a progressive improvement in size and fatness. When they arrive in Chesapeake Bay, in the spring, they are thin and lean, and appear to be sluggish and stupid, so that they are easily caught—can almost be taken out by the hand along the shore, which many of them follow closely. Between Virginia and Maine the increase in weight is thought to be one-third. In the fall the increase still continues, but the order of it is reversed, the fish appearing to grow larger the farther South they go, and on reaching Virginia again are twice as heavy as in the spring, and have so gained in strength, swiftness, and wariness that they are very hard to catch."*

Mr. Dudley tells me that from his experience of two years he knows that the first runs of fish in the Chesapeake are fat. This is in March and April.

Mr. A. C. Davis states that the June fish at Beaufort yield from $\frac{3}{4}$ to 1 gallon, those in October and November 4 to 5 gallons.

Mr. W. F. Hatsel, of Body's Island, states that the average yield is $1\frac{1}{2}$ gallons to the barrel, 75 gallons to the ton of scrap.

Comparison of yield in different localities.

256. These statements indicate in a general way that the yield of Northern is greater than that of Southern fish, though the disparity is not so

---

* Boardman and Atkins, op. cit., p. 6.

great in the latter part of the season. Mr. Davis' estimate for Beaufort is, however, not much below the average of the coast south of Maine, and it is quite possible that the apparent disparity of the yield on the Southern coast (of which we are not really entitled to judge with the meager returns before us) would be in part explained by differences in the modes of manufacture. Florida menhaden are many of them very fat in the winter season, and there is no apparent reason why the manufacture of oil and guano may not be successfully carried on on our Southern coast.

The official returns of manufacturers may add some additional facts in reference to the yield of fish in oil and guano and the comparative advantages of location.

The following table and statement, quoted from Mr. Maddocks, give a comparative view of the manufacture as carried on by the Maine Association and by all the rest of the United States for the year 1876, the latest for which the data are at hand for the whole country.

Locality.	No. of men.	No. of vessels.	No. of steamers.	Total capital.	Barrels fish used.	Gallons oil manufactured.	Tons crude guano manufactured.
Other States...	1,629	291	3	$1,767,000	826,885	848,727	29,831
Maine.........	1,129	29	43	983,000	709,000	2,143,273	21,414

The most striking fact brought out in the comparison is that Maine realized, from 46 per cent. of the fish, 71 per cent. of the oil. To this it may be added that from the use of $983,000 capital Maine turned out a total product of $1,071,449 value, whereas the rest of the country realized $637,600 from $1,767,000.

45. STATISTICS OF THE MANUFACTURE OF OIL AND GUANO.

Returns for the State of Maine.

257. The number of gallons of oil produced at the factories of the Maine Association during the past five years is as given below:

1873	1,204,055
1874	1,931,037
1875	1,514,881
1876	2,143,273
1877	1,166,213
Total	7,959,459

Table showing average number of vessels employed in fisheries of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	5	3	3	2	....
Judson, Tarr & Co	Pemaquid, Me	2	1	....	....	....
Albert Gray & Co	Round Pond, Me	1	1	1	1	1
Jos. Church & Co	......do	2	3	2	2	2
Gallup, Morgan & Co	East Boothbay, Me	3	2	2	1	....
W. A. Wells & Co	South Bristol, Me	2	2	1	....	....
Gallup & Holmes	East Boothbay, Me	3	4	2	....	....
Kenniston, Cobb & Co	Boothbay, Me	4	5	5	4	....
Atlantic Oil Company	......do	6	3	....	....	....
Round Pond Oil Works	Round Pond, Me	3	6	3	4	4
Bristol Oil Works	......do	....	....	2	2	....
Suffolk Oil Works	......do	5	4	....	3	1
Loud's Island Oil Works	......do	2	2	2	3	2
R. A. Friend	Brooklin, Me	....	1	....	....	....
Tuthill & Co	South Bristol, Me	....	....	1	1	....
J. G. Nickerson & Co	Hodgdon's Mills, Me	....	....	5	....	....
John Hastings	Round Pond, Me	....	....	3	....	....
Fowler & Foote	South Bristol, Me	....	....	2	3	3
George W. Miles & Co	......do	....	....	2	....	....
Job T. Wilson	Blue Hill, Me	....	....	....	....	....
Pemaquid Oil Company	Pemaquid, Me	....	....	....	....	....
Brown's Cove Oil Company	Round Pond, Me	....	....	....	3	....
Maddocks' Oil Works	Boothbay, Me	....	....	....	....	....
South Saint George Oil Works	South Saint George, Me	....	....	....	....	....

Table showing amount of capital employed by manufacturers of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	$90, 000	$90, 000	$90, 000	$110,000	$90, 000
Judson, Tarr & Co	Pemaquid, Me	110, 000	120, 000	....	....	....
Albert Gray & Co	Round Pond, Me	28, 000	55, 000	50, 000	45, 000	55, 000
Jos. Church & Co	......do	120, 000	120, 000	145, 000	155, 000	200, 000
Gallup, Morgan & Co	East Boothbay, Me	19, 000	24, 000	31, 000	35, 000	44, 612
W. A. Wells & Co	South Bristol, Me	27, 000	35, 000	40, 000	40, 000	60, 000
Gallup & Holmes	East Boothbay, Me	22, 000	25, 000	50, 000	54, 000	70, 000
Kenniston, Cobb & Co	Boothbay, Me	27, 000	30, 000	25, 000	25, 000	25, 000
Atlantic Oil Company	......do	65, 000	100, 000	140, 000	135, 000	....
Round Pond Oil Works	Round Pond, Me	16, 000	18, 000	20, 000	12, 000	21, 000
Bristol Oil Works	......do	28, 000	20, 000	22, 000	16, 000	35, 000
Suffolk Oil Works	......do	55, 000	55, 000	....	80, 000	45, 000
Loud's Island Oil Works	......do	6, 500	8, 000	8, 000	8, 000	25, 000
R. A. Friend	Brooklin, Me	....	6, 500	....	....	....
Tuthill & Co	South Bristol, Me	....	....	28, 000	38, 000	42, 000
J. G. Nickerson & Co	Hodgdon's Mills, Me	....	....	90, 000	....	....
John Hastings	Round Pond, Me	....	....	23, 000	....	....
Fowler & Foote	South Bristol, Me	....	....	36, 000	48, 000	42, 000
George W. Miles & Co	......do	....	....	57, 000	57, 000	59, 000
Job T. Wilson	Blue Hill, Me	....	....	24, 000	....	....
Pemaquid Oil Company	Pemaquid, Me	....	....	....	110, 000	100, 000
Brown's Cove Oil Company	Round Pond, Me	....	....	....	15, 000	23, 000
Maddocks' Oil Works	Boothbay, Me	....	....	....	....	130, 000
South Saint George Oil Works	South Saint George, Me	....	....	....	....	37, 000

Table showing average number of tons of crude guano produced by the manufacturers of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	1, 500	2, 600	2, 500	1, 450	....
Judson, Tarr & Co	Pemaquid, Me	1, 800	2, 150	....	....	....
Albert Gray & Co	Round Pond, Me	750	1, 350	1, 680	1, 300	800
Jos. Church & Co	......do	2, 100	4, 000	4, 500	6, 000	5, 400
Gallup, Morgan & Co	East Boothbay, Me	680	900	1, 016	1, 100	700
W. A. Wells & Co	South Bristol, Me	700	900	510	1, 000	562
Gallup & Holmes	East Boothbay, Me	470	790	900	1, 230	1, 500
Kenniston, Cobb & Co	Boothbay, Me	615	850	714	483	....
Atlantic Oil Company	......do	1, 800	2, 450	2, 000	1, 595	....
Round Pond Oil Works	Round Pond, Me	450	850	550	660	150
Bristol Oil Works	......do	600	800	800	800	600
Suffolk Oil Works	......do	1, 300	950	....	850	740
Loud's Island Oil Works	......do	200	500	400	....	275
R. A. Friend	Brooklin, Me	....	205	....	....	....
Tuthill & Co	South Bristol, Me	....	....	500	825	800
J. G. Nickerson & Co	Hodgdon's Mills Me	....	....	1, 375	....	....
John Hastings	Round Pond, Me	....	....	400	....	....
Fowler & Foote	South Bristol, Me	....	....	450	825	562
George W. Miles & Co	......do	....	....	850	1, 121	725
Job T. Wilson	Blue Hill, Me	....	....	250	....	....
Pemaquid Oil Company	Pemaquid, Me	....	....	....	2, 000	1, 900
Brown's Cove Oil Company	Round Pond, Me	....	....	....	175	....
Maddocks' Oil Works	Boothbay, Me	....	....	....	....	1, 600
South Saint George Oil Works	South Saint George, Me	....	....	....	....	352

Table showing average number of barrels of fish taken by fleet belonging to Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	49, 000	82, 000	83, 000	48, 000	....
Judson, Tarr & Co	Pemaquid, Me	61, 000	67, 000	....	....	....
Albert Gray & Co	Round Pond, Me	25, 000	46, 000	53, 000	45, 000	27, 000
Jos. Church & Co	......do	86, 000	138, 000	153, 000	201, 000	182, 000
Gallup, Morgan & Co	East Boothbay, Me	22, 000	29, 472	29, 545	34, 763	23, 760
W. A. Wells & Co	South Bristol, Me	22, 913	30, 000	28, 000	30, 000	19, 200
Gallup & Holmes	East Boothbay, Me	15, 000	25, 000	32, 000	40, 900	51, 847
Kenniston, Cobb & Co	Boothbay, Me	18, 000	28, 389	21, 323	14, 474	....
Atlantic Oil Company	......do	43, 000	64, 000	56, 000	51, 878	....
Round Pond Oil Works	Round Pond, Me	16, 500	27, 000	18, 000	22, 000	5, 500
Bristol Oil Works	......do	22, 000	33, 000	24, 000	25, 653	22, 500
Suffolk Oil Works	......do	41, 000	29, 000	....	26, 916	22, 200
Loud's Island Oil Works	......do	8, 000	15, 000	12, 300	13, 000	9, 600
R. A. Friend	Brooklin, Me	....	8, 000	....	....	....
Tuthill & Co	South Bristol, Me	....	....	16, 583	27, 960	27, 176
J. G. Nickerson & Co	Hodgdon's Mills, Me	....	....	43, 620	....	....
John Hastings	Round Pond, Me	....	....	14, 000	....	....
Fowler & Foote	South Bristol, Me	....	....	16, 000	26, 230	17, 721
George W. Miles & Co	......do	....	....	25, 000	37, 000	20, 000
Job T. Wilson	Blue Hill, Me	....	....	10, 400	....	....
Pemaquid Oil Company	Pemaquid, Me	....	....	....	60, 000	64, 031
Brown's Cove Oil Company	Round Pond, Me	....	....	....	5, 000	....
Maddocks' Oil Works	Boothbay, Me	....	....	....	....	51, 610
South Saint George Oil Works	South Saint George, Me	....	....	....	....	13, 000

Table showing average number of gallons of oil produced by manufacturers of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	135, 000	260, 000	20, 000	146, 000	....
Judson, Tarr & Co	Pemaquid, Me	175, 000	200, 000	....	....	....
Albert Gray & Co	Round Pond, Me	70, 000	153, 665	135, 000	129, 000	44, 000
Jos. Church & Co	......do	250, 000	450, 000	446, 000	600, 000	365, 781
Gallup, Morgan & Co	East Boothbay, Me	55, 000	88, 264	75, 017	111, 018	47, 880
W. A. Wells & Co	South Bristol, Me	62, 000	93, 000	76, 000	87, 000	40, 000
Gallup & Holmes	East Boothbay, Me	45, 000	71, 000	86, 000	135, 555	121, 000
Kenniston, Cobb & Co	Boothbay, Me	53, 800	84, 108	56, 656	39, 500	....
Atlantic Oil Company	......do	120, 000	193, 000	140, 000	139, 000	....
Round Pond Oil Works	Round Pond, Me	43, 255	87, 000	45, 000	72, 000	8, 500
Bristol Oil Works	......do	55, 000	102, 000	70, 000	80, 000	53, 500
Suffolk Oil Works	......do	120, 000	83, 000	....	82, 500	51, 000
Loud's Island Oil Works	......do	20, 000	44, 000	30, 000	28, 000	15, 680
R. A. Friend	Brooklin, Me	....	22, 000	....	....	....
Tuthill & Co	South Bristol, Me	....	....	48, 428	89, 000	65, 000
J. G. Nickerson & Co	Hodgdon's Mills, Me	....	....	114, 380	....	....
John Hastings	Round Pond, Me	....	....	37, 000	....	....
Fowler & Foote	South Bristol, Me	....	....	36, 400	85, 000	39, 872
George W. Miles & Co	......do	....	....	71, 000	124, 700	45, 000
Job T. Wilson	Blue Hill, Me	....	....	28, 000	....	....
Pemaquid Oil Company	Pemaquid, Me	....	....	....	180, 000	130, 000
Brown's Cove Oil Company	Round Pond, Me	....	....	....	15, 000	....
Maddocks' Oil Works	Boothbay, Me	....	....	....	....	118, 000
South Saint George Oil Works	South Saint George, Me	....	....	....	....	21, 000

Table showing average number of steamers employed in fisheries of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	3	4	4	4	....
Judson, Tarr & Co	Pemaquid, Me	4	4	....	....	....
Albert, Gray & Co	Round Pond, Me	1	2	3	3	4
Jos. Church & Co	......do	4	4	5	7	8
Gallup, Morgan & Co	East Boothbay, Me	....	1	....	2	2
W. A. Wells & Co	South Bristol, Me	1	1	2	2	3
Gallup & Holmes	East Boothbay, Me	....	....	2	3	4
Kenniston, Cobb & Co	Boothbay, Me	....	....	....	1	....
Atlantic Oil Company	......do	1	3	6	6	....
Round Pond Oil Works	Round Pond, Me	....	....	....	....	....
Bristol Oil Works	......do	2	2	1	1	3
Suffolk Oil Works	......do	1	1	....	2	2
Loud's Island Oil Works	......do	....	....	....	....	1
R. A. Friend	Brooklin, Me	....	....	....	....	....
Tuthill & Co	South Bristol, Me	....	....	1	2	3
J. G. Nickerson & Co	Hodgdon's Mills, Me	....	....	3	....	....
Job T. Wilson	Blue Hill, Me	....	....	1	....	....
Pemaquid Oil Company	Pemaquid, Me	....	....	....	4	5
Brown's Cove Oil Company	Round Pond, Me	....	....	....	....	....
John Hastings	......do	....	....	....	....	....
Fowler & Foote	South Bristol, Me	....	....	1	2	2
George W. Miles & Co	......do	....	....	2	2	2
Maddocks' Oil Works	Booth Bay, Me	....	....	....	....	6
South Saint George Oil Works	South Saint George, Me	....	....	....	....	2

Table showing aggregate number of men employed in fisheries of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	80	80	96	60	(*)
Judson, Tarr & Co	Pemaquid, Me	60	50	......	......	......
Albert, Gray & Co	Round Pond, Me	15	24	40	50	50
Jos. Church & Co	......do	60	70	100	120	140
Gallup, Morgan & Co	East Boothbay, Me	27	27	37	†35	28
W. A. Wells & Co	South Bristol, Me	25	20	32	30	40
Gallup & Holmes	East Boothbay, Me	36	50	†50	40	60
Kenniston, Cobb & Co	Boothbay, Me	40	50	50	50	(*)
Atlantic Oil Company	......do	60	60	60	60	......
Round Pond Oil Works	Round Pond, Me	30	30	30	40	50
Bristol Oil Works	......do	20	20	30	30	40
Suffolk Oil Works	......do	60	50	......	50	28
Loud's Island Oil Works	......do	20	20	20	20	42
R. A. Friend	Brooklin, Me	......	10	......	......	......
Tuthill & Co	South Bristol, Me	......	......	20	30	30
J. G. Nickerson & Co	Hodgdon's Mills, Me	......	......	80	......	......
John Hastings	Round Pond, Me	......	......	30	......	......
Fowler & Foote	South Bristol, Me	......	......	36	38	42
George W. Miles & Co	......do	......	......	50	25	30
Job T. Wilson	Blue Hill, Me	......	......	10	......	......
Pemaquid Oil Company	Pemaquid, Me	......	......	......	50	65
Brown's Cove Oil Company	Round Pond, Me	......	......	......	30	(*)
Maddocks' Oil Works	Boothbay, Me	......	......	......	......	66
South Saint George Oil Works	South Saint George, Me	......	......	......	......	26

* Not operated. † Hodgdon's Mills, E. B.

Table showing aggregate number of men employed in factories of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	30	40	45	40	(*)
Judson, Tarr & Co	Pemaquid, Me	27	30	......	......	......
Albert Gray & Co	Round Pond, Me	17	20	30	30	30
Jos. Church & Co	......do	50	70	80	50	60
Gallup, Morgan & Co	East Boothbay, Me	9	13	†17	15	15
W. A. Wells & Co	South Bristol, Me	15	16	17	18	12
Gallup & Holmes	East Boothbay, Me	10	12	†18	18	20
Kenniston, Cobb & Co	Boothbay, Me	11	10	12	17	(*)
Atlantic Oil Company	......do	24	20	25	25	......
Round Pond Oil Works	Round Pond, Me	15	15	16	15	15
Bristol Oil Works	......do	15	16	20	13	15
Suffolk Oil Works	East Boothbay, Me	16	16	......	15	18
Loud's Island Oil Works	Round Pond, Me	10	12	9	12	12
R. A. Friend	Brooklin, Me	......	14	......	......	......
Tuthill & Co	South Bristol, Me	......	......	11	14	13
J. G. Nickerson & Co	Hodgdon's Mills, Me	......	......	13	......	......
John Hastings	Round Pond, Me	......	......	18	......	......
Fowler & Foote	South Bristol, Me	......	......	18	14	13
George W. Miles & Co	......do	......	......	15	20	15
Job T. Wilson	Blue Hill, Me	......	......	13	......	......
Pemaquid Oil Company	Pemaquid, Me	......	......	......	40	‡30
Brown's Cove Oil Company	Round Pond, Me	......	......	......	12	(*)
Maddocks' Oil Works	Boothbay, Me	......	......	......	......	20
South Saint George Oil Works	South Saint George, Me	......	......	......	......	12

* Not operated. † Hodgdon's Mills. ‡ Bristol, Me.

Table showing statistics of the manufacture of oil and guano in the State of Maine.

	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Number of factories	......	......	13	14	17	17	18
Number of sail-vessels	......	......	38	37	36	29	13
Number of steamers	......	......	17	22	31	43	48
Number of fishermen	......	......	533	561	771	758	727
Number of factory hands	......	......	249	304	373	371	300
Number of men—total	......	......	782	865	1, 144	1, 129	1, 027
Capital in factories	......	......	$278, 500	$316, 000	$397, 000	$431, 000	$459, 812
Capital in gear	......	......	$335, 000	$390, 500	$482, 000	$552, 000	$623, 800
Capital—total	......	......	$613, 500	$706, 500	$879, 000	$983, 000	$1, 083, 612
Number of fish (bbls)	......	......	429, 413	621, 861	635, 771	709, 000	557, 145
Number of fish (M)	......	......	143, 137, 666	207, 287, 000	211, 923, 666	238, 333, 000	185, 715, 000
Gallons of oil	......	......	1, 204, 055	1, 931, 037	1, 514, 881	2, 143, 273	1, 166, 213
Tons of guano	......	16, 000	12, 965	19, 295	19, 395	21, 414	16, 666

Returns for the United States.

258. The following table, compiled from data furnished by Mr. Jasper Pryer, shows in detail the statistics of manufacture by some of the principal establishments:

	Number of men employed.		Number of vessels.		Fish caught.		Quantity of products.		Tons guano dried.	Capital.
	In factory work.	In fishing.	Sailing-vessels.	Steamers.	Barrels.	Number.	Gallons oil.	Tons guano.		
MAINE.										
Bristol Oil Works	15	40	....	3	22, 700	....	53, 500	600	....	$35, 000
Albert Gray & Co	30	50	1	4	27, 300	....	44, 000	800	....	55, 000
Joseph Church & Co	60	140	2	8	182, 700	....	365, 781	5, 400	....	200, 000
Round Pond Oil Company	13	30	....	3	30, 413	....	65, 000	800	....	42, 000
Loud's Island Oil Company	12	42	2	1	9, 600	....	15, 680	275	....	25, 000
Pemaquid Oil Company	30	65	....	5	65, 539	....	139, 000	1, 900	....	100, 000
Wells & Co	12	40	....	3	19, 700	....	40, 000	562	....	60, 000
Tuthill, French & Co	15	50	4	1	5, 500	....	8, 500	150	....	21, 000
Fowler, Foot & Co	13	42	3	2	18, 060	....	39, 872	562	....	42, 000
Suffolk Oil Company	18	28	1	2	23, 400	....	51, 000	740	....	45, 000
Gallup & Holmes	20	60	....	4	51, 947	....	121, 000	1, 500	....	70, 000
Gallup, Morgan & Co	15	28	....	2	23, 910	....	47, 880	700	....	44, 612
Maddocks' Oil Works	20	66	....	6	53, 110	....	118, 000	1, 600	....	130, 000
Robert A. Frend	7	23	2	....	6, 000	....	1, 500	135	....	5, 500
The George W. Miles Company	15	30	....	2	21, 000	....	45, 000	72, 500	....	59, 000
MASSACHUSETTS.										
Erskine Pierce	10	10	4	....	15, 000	....	19, 000	450	....	11, 000
RHODE ISLAND.										
Job T. Wilson & Co	15	40	9	1	53, 000	....	66, 250	1, 590	....	40, 000
William J. Brightman & Co	14	30	6	1	50, 000	....	61, 081	1, 500	....	20, 000
Isaac Brown & Co	15	40	12	....	13, 563	....	18, 350	461	....	9, 000
Charles Cook	10	20	3	1	26, 060	....	32, 500	780	....	18, 000
Isaac G. White	14	20	....	2	80, 000	....	22, 500	540	....	35, 000
James Manchester	8	10	3	....	4, 000	....	5, 000	120	....	3, 000
W. H. H. Howland	20	30	6	1	....	13, 000, 000	43, 000	1, 100	....	20, 000
CONNECTICUT.										
G. S. Allyn & Co	15	45	9	1	....	13, 000, 000	41, 200	1, 200	200	25, 000
Leander, Wilcox & Co	16	30	9	....	....	9, 000, 000	27, 000	1, 000	....	30, 000
Waley & Co	7	18	4	....	....	4, 500, 000	14, 600	200	60	15, 000
Quinnipiac Fertilizer Company	25	40	6	1	....	13, 000, 000	43, 000	11, 100	600	110, 000
Luce Brothers	30	50	12	1	....	23, 000, 000	76, 500	900	1, 100	50, 000
J. H. Bishop	8	15	4	....	....	5, 000, 000	18, 200	520	....	9, 000

E. R. Kelsey	8	10	3			4, 800, 000	22, 000	600		8, 000
The George W. Miles Company	20	40	12			15, 000, 000	43, 000	1, 100	600	45, 000
Fowler & Colburn	20	45	12	*5		13, 192, 400	49, 250	1, 411		47, 000
Westbrook Oil Company	6				7, 000		8, 750	210		1, 000
NEW YORK.										
Eleven factories in Gardiner's Bay	159	298	69	4		131, 500, 000	394, 500	14, 600	2, 500	310, 000
G. H. Clark	4	4	2			600, 000	1, 600	60		500
W. Y. Fithian & Co	11	22	6			10, 000, 000	25, 000	12, 000		20, 000
Smith & Yarrington	15	20	4			8, 600, 000	22, 000	800		15, 000
Barron Island Manufacturing Company	22	40	12			13, 150, 000	32, 854	1, 160	200	17, 500
S. Jones & Co	22	48	12			14, 686, 725	36, 266	1, 545		30, 000
NEW JERSEY.										
Griffin & Vail	12	11	6			9, 000, 000	22, 500	1, 000	50	10, 000
James E. Otis	9	11	3			2, 500, 000	5, 000	250		11, 000
Cyrus H. Smith	8	9	2			3, 406, 000	7, 400	350		7, 000
Morris & Fifield	6	8	2			1, 053, 000	2, 375	105		5, 000

* Fishing off Sandy Hook.

The following table shows the aggregate statistics for the United States for a period of five years:

Table showing statistics of the manufacture of menhaden oil and guano in the United States in the years 1873, 1874, 1875, 1876, *and* 1877.

[Compiled from the Annual Reports of the United States Menhaden Oil and Guano Association.]

	1873.	1874.	1875.	1876.	1877.
Number of factories in operation	62	64	60	64	56
Number of sail-vessels employed	383	283	304	320	270
Number of steam-vessels employed	20	25	39	46	63
Number of men employed is fisheries	1, 109	871	....	....	....
Number of men employed in factories	1, 197	1, 567	....	....	....
Total number of men employed	2, 306	2, 438	2, 633	2, 758	2, 631
Amount of capital invested	$2, 388, 000	$2, 500, 000	$2, 650, 000	$2, 750, 000	$2, 047, 612
Number of fish taken	397, 700, 000	492, 878, 000	563, 327, 000	512, 450, 000	587, 624, 125
Number of fish taken (estimated in barrels)	1, 193, 100	1, 478, 634	1, 877, 767	*1, 535, 885	1, 958, 747
Number of gallons of oil made	2, 214, 800	3, 372, 837	2, 681, 487	2, 992, 000	2, 426, 589
Number of tons of guano made	36, 299	50, 976	53, 625	51, 245	55, 444
Number of gallons of oil held by manufacturers at the end of the year	484, 520	648, 000	125, 000	264, 000	94, 000
Number of tons of guano held by manufacturers at the end of the year	2, 700	5, 200	1, 850	7, 275	2, 840
Value of oil, at 37 cents	$819, 476	$1, 247, 950	$992, 140	$1, 107, 040	$997, 838
Value of guano, at $11	$399, 199	$560, 736	$589, 875	$503, 695	$609, 884
Total value of manufactured products	$1, 218, 675	$1, 808, 686	$1, 582, 015	$1, 670, 735	$1, 607, 722

* The Oil, Paint, and Drug Reporter for January 9, 1877, gives this as 1,708,166.

A comparison of the yield of the whale and other fisheries.

259. In 1875, the total amount of sperm oil from the American whale fisheries was 1,000,951 gallons; of other whale oil, 1,414,186 gallons; in all, 2,505,137 gallons. The amount of menhaden oil for the same year was 2,618,487 gallons, an excess of 176,350 gallons. In 1874, the amount of menhaden oil was 3,372,837 gallons, exceeding that of whale oil by 1,115.597 gallons.

In 1876, 2,990,000 gallons of menhaden oil were made, and in 1877, 2,426,000, For the year ending June 30, 1877, the production of whale oil was 2,140,047 gallons, and for the year 1877, 2,151,765 gallons.

In the "Oil, Paint, and Drug Reporter" for January 14, 1874 (page 4), the following statement is made:

"It is asserted that while the amount of oil produced is equal to that derived from the whale fisheries in this country, the menhaden interest is ahead of the whale, for though the menhaden oil sells at a less price per gallon, for every barrel of oil made there is three-quarters of a ton of scrap, which readily commands $15 per ton at the factory."

This is not true. In 1874, for instance, the value of the sperm oil alone was $1,250,987; that of other oils from the whale fishery, $775,919. Total value of oils from the whales, $2,026,906; the value of the total products of the whale fishery, $2,291,896.

By way of further comparison, the cod and seal-oil fishery of Newfoundland and Labrador may be instanced. The latest figures at hand show the product of the seal-oil fishery to be 1,500,000 gallons, and of the cod-oil fishery 900,000.

Comparison of yield of nitrogen from Guano Islands.

260. The refuse products of the oil-factories, together with the fish used in a crude state for manure, are estimated to have yielded in 1875 over 10,000,000 pounds of ammonia in the best possible organic forms. This quantity of ammonia is equivalent to at least 60,000,000 pounds of Chincha Island guano, formerly imported from Peru, the gold value of which would be not far from $1,920,000.

In addition to ammonia, the phosphate of lime derived from this source and convertible into agricultural products amounted to nearly 1,430,000 pounds, which is the equivalent of nearly 60,000,000 pounds of Peruvian guano.

Associations of oil and guano manufacturers.

261. The Association of the Menhaden Oil and Guano Manufacturers of Maine was formed in the year 1870. The objects were such as are usually sought by organizations of the sort—harmony of action on points affecting the common welfare of the business, social acquaintance, and the communication of information as to improved processes, etc. The annual meeting is held the second Tuesday in January of each year. The United States Menhaden Oil and Guano Association was organized in 1873. The annual reports of these societies are given in full in Appendix L.

46. THE USES OF MENHADEN OIL AND THE OIL MARKET.

The uses of menhaden oil.

262. The uses of menhaden oil are manifold. It is chiefly employed as a substitute for the more costly and popular oils and to adulterate them. It is sold largely to tanneries for currying leather. After the hide has been "dressed," *i. e.*, after its coarser fleshy parts have been pared off, the oil, mixed with tallow, is applied. This is technically called "stuffing," and results in qualifying any residue of alkali left from the "liming" process, and in filling the pores, and softening the leather. Mr. L. C. d'Homergue states that this oil is largely used in the tanneries of Russia.

A considerable quantity is used as a burning oil in coal-mines to fill the small lamps, one of which is fastened to the cap of each miner. It is then mixed with paraffine or some of the heavier oils. Some is also sold to be used in the manufacture of rope. A small quantity is used annually for lubricating purposes, but, on account of its gummy nature, it is not much in favor among machinists.* It is used in adulterating linseed oil, and is also sold as a substitute, its cheapness and durability

*Mr. Isaac Bow, of Springfield, Mass., devoted several years to experimenting, with a view to the preparation of a good lubricating oil from menhaden oil, but his success was not satisfactory.

rendering it especially valuable for rough outside work and for painting ships. Mixed with other oils it is found to be very serviceable for the painting of interiors, and its use is attended with decided economy, its price being about one-half that of the best linseed oil. Some of the most pure is said to be put into the market as olive oil.

Most of that which is exported is used in the manufacture of soap and for smearing sheep after they have been sheared to keep off ticds. Mr. L. C. d'Homergue states in the Manufacturer and Builder that a bright fish oil, cut with some alcohol and mixed with paint, forms a far more lasting covering than linseed oil.

The "Oil, Paint, and Drug Reporter" for October 21, 1874, implies that much of the whale oil now sold is really menhaden oil. "It is well known that the chief uses for menhaden oil is for currying leather, but with the low prices ruling of late and the scarcity of whale-oil it has found new channels, and very much of the whale-oil sold probably consists of two-thirds or more of menhaden, for it comes when crude nearly as handsome as any whale, and in appearance when bleached is quite equal. It is reported as a fact about the street that one concern alone sells more 'winter-bleached whale-oil' than is caught of crude, and they do not by any means get all the crude."

The markets.

263. The principal market for menhaden oil is in Boston and New York; some is also sold in New Bedford, and considerable quantities are shipped to London, Liverpool, and Havre direct.

Grades of oil.

264. Several grades are recognized. The "Oil, Paint, and Drug Reporter" usually quotes under the heads of "select light strained," "select light," "choice brown," and "inferior to dark," and "gurry."

The prices of oil.

265. The highest price ever obtained for menhaden oil was $1.40 a gallon—this was a war price. In Appendix K is given a table showing the current weekly prices of the different grades of oil in the New York market for a period of nearly seven years. This has been compiled from the "Oil, Paint, and Drug Reporter," complete files of which I have been enabled to consult through the courtesy of the editor, Mr. W. O. Allison. This table includes all reliable information regarding the prices current of menhaden oil, and its value is enhanced by the addition of a weekly commentary upon the causes of fluctuation in price and the state of the market, also compiled from the "Oil, Paint, and Drug Reporter." Since the interest in the causes of rise and fall of price is of merely commercial interest, it does not seem to be necessary in this place to discuss the subject in detail. See Appendix K.

Table showing highest and lowest prices of menhaden oil for the years 1871 to 1877.

Years.	Select light.	Choice brown.	Inferior to dark.	Gurry.	Strained.	Pressed.	Select light, strained.	Bleached.
1871	53 to 55	50 to 52½	47½ to 50	35 to 40	60 to 62½	....	....	....
	40½ to 41	39½ to 40	35 to 38	20 to 25	58 to 60	....	....	....
1872	62½ to 65	60 to 62½	55 to 57½	45 to 50	60 to 65	64 to 66	....	....
	40 to 42½	40 to 41	36 to 38	25 to 30	58 to 65	45 to 50	....	....
1873	60 to 62	59 to 60	52 to 58	48 to 50	....	55 to 57½	....	....
	32½ to 35	30 to 32	29 to —	....	....	....	....	....
1874	45 to 47½	45 to 46	42½ to 45	....	....	....	52½ to 55	....
	32½ to 35	35 to 35½	32 to 34	....	....	....	40 to 42	....
1875	45 to 47½	43 to 44	38 to 40	....	....	....	49 to 50	55 to 56
	32 to 33	31 to 32	20 to 30	....	....	....	38 to —	44 to 45
1876	48 to 50	46 to 48	36 to —	....	....	....	50 to 52½	55 to 60
	32½ to 33	32½ to 33	34 to 36	....	....	....	40 to 41	45 to 47
1877	46 to 47	45 to 46	40 to 42	....	....	....	48 to 50	53 to 54
	33 to 34	33 to 34	30 to 32	....	....	....	38 to 40	42½ to 45

Reviews of the markets.

266. in January, 1874, the manufacturers composing the "United States Menhaden Oil and Guano Association" had on hand 484,520 gallons of oil, or about 21 per cent. of the amount manufactured in 1873; in January, 1875, 648,000 gallons, or about 19 per cent.; in January, 1876, 125,000, or over 4 per cent.; in January, 1877, 264,000, or over 8 per cent.; and in January, 1878, 94,000, or over 4 per cent. These figures seem to indicate that the demand for oil quite keeps pace with the supply.

The following editorial on the value of menhaden oil appeared in the Oil, Paint and Drug Reporter, October 21, 1874:

"Prices for menhaden oil have ruled very low this year, and it has probably been relatively the cheapest grease in market. This fact, together with a poor run of fish part of the season, caused several of the weakest of the manufacturers to close their works, and the natural result has been less than an average season's production, except in Maine. The Maine season ended some time since, and the fall catch of the other States, which is usually the best, has thus far been comparatively nothing, and as it will soon close cannot be improved much. To-day we should estimate the stock in the hands of fishermen as fully one quarter less than last year, and with one exception the dealers in this city are almost without stock.

"The entire failure of the Arctic whaling-fleet, the high price of all other grease, and the advance in the price of Newfoundland cod oil point to advanced prices for menhaden. We said early in the season that menhaden oil was cheap at 40 cents, and it ought not to have gone below that price. At the present time some parties talk of 50 cents as the point the market will reach, but we hope that manufacturers will not hold for such high prices; this would be as much too high as 35 cents was too low, and as soon as you get an article above its real value something takes its place and you cannot get it into the same channels until it becomes so low that it is forced back."

N.—MENHADEN AND OTHER FISH AND THEIR PRODUCTS AS RELATED TO AGRICULTURE.

By W. O. Atwater.

Introductory note.

267. Mr. Goode has placed in my hands a number of documents, manuscripts, and letters concerning the use of fish, and particularly menhaden, as fertilizers, with a request for a statement of the more important facts and principles that have to do with the application of these materials to the improvement of agriculture.

The time allowed for this work is, unfortunately, so short as to forbid anything more than a hasty putting together of the data immediately at hand, in the form of a brief review of the history and a still more incomplete outline of the results of scientific investigation and practical experience concerning the preparation, properties, and uses of fish as a fertilizer and as food for stock. I hope that this may serve to explain the chief practical bearings of the subject, to show its importance, and lead to its more thorough investigation hereafter.

The employment of fish products in agriculture offers a singularly forcible illustration of the slowness with which the worth of some of the most valuable materials is recognized, and of the need of scientific investigation and experiment to aid practical skill in utilizing them most profitably.

The loss to the agriculture of our country at large, and particularly our sea-board States, from the waste of fish that might be utilized, the wrong manufacture of the materials that are saved, the export of the best products to Europe, the uneconomical use as fertilizers of what we save and keep at home, and from the almost entire neglect to devote the products to their most profitable purpose, feeding stock and enriching the manure of the farm, if it were capable of accurate estimate, could not fall short of some millions of dollars annually. This is due mainly to the fact that the principles that underlie the right economizing of fish are not generally understood, and, for that matter, are not yet fully learned. It is only lately that science has joined with practice in studying and improving the manufacture and use of fish products for agricultural purposes. The best work in investigation has been done in Europe; its results come to us but tardily. Manufacturers hesitate to apply and farmers are still slower to use them. Everything that brings new knowledge or extends the understanding of what is known must, then, be most valuable.

47. MENHADEN AND OTHER FISH IN A FRESH STATE USED AS A FERTILIZER.

Use among the Indians and early colonists.

268. Professor Trumbull tells us that the Indian names of *Brevoortia*, "menhaden" and "poghaden" (pogy), mean "fertilizer," that which manures, and that the Indians were accustomed to employ this species, with others of the herring tribe (aumsûog and munnawhateaûg), mostly the alewife (*Pomolobus pseudoharengus*), in enriching their corn-fields. Thomas Morton wrote in 1632, of Virginia: "There is a fish (by some called shadds, by some allizes) that at the spring of the yeare passe up the rivers to spawn in the ponds, & are taken in such multitudes in every river that hath a pond at the end that the inhabitants doung their grounds with them. You may see in one township a hundred acres together, set with these fish, every acre taking 1,000 of them, & an acre thus dressed will produce and yeald so much corne as 3 acres without fish; & (least any Virginea man would inferre hereupon that the ground of New England is barren, because they use no fish in setting their corne, I desire them to be remembered, the cause is plaine in Virginea) they have it not to sett. But this practice is onely for the Indian maize (which must be set by hands), not for English grain: & this is, therefore, a commodity there." *

This passage is very interesting, showing the use of fish fertilizers in Virginia two hundred and fifty years ago or more, and, from what is known of the habits of the herring family in Virginia rivers and the persistency of local names, there can be little doubt that many menhaden were used among the fertilizing fish, though "shadds and allizes" doubtless includes the shad (*Alosa sapidissima*), the mattowocca (*Pomolobus mediocris*), the alewife (*Pomolobus pseudoharengus*), and the thread-herring (*Dorosoma cepedianum*), all of which are common in spring in the Potomac and other rivers which empty into Chesapeake Bay.

In Governor Bradford's "History of Plimoth Plantation" an account is given of the early agricultural experiences of the Plymouth colonists. In April, 1621, at the close of the first long dreary winter, "they (as many as were able) began to plant their corne, in which service Squanto (an Indian) stood them in great stead, showing them both y^e^ manner how to set it and after how to dress & tend it. Also he tould them, axcepte they got fish & set with it (in these old grounds) it would come to nothing; and he showed them y^t^ in y^e^ midle of Aprill, they should have store enough come up y^e^ brooke by which they begane to build, and taught them how to take it." †

* New England Canaan; or New Canaan, containing an abstract of New England. Composed in three Bookes. * * * Written by Thomas, of Clifford's Inn, Gent. Upon ten Yeers knowledge & Experiment of the Country. Printed by Charles Green, 1632. Force's Historical Tracts, Vol. II, .?

† Coll. Mass. Hist. Soc., III, 4th series, 1856, p. 100.

An allusion to the practice of the Indians in this respect may be found in George Mourt's "Relation or Journal of the beginning and Proceedings of the English Plantation settled at Plimoth, in New England, by certain English Adventurers both Merchants and others." * * * "London, 1622": "We set the last spring some twenty acres of Indian corn, and sowed some six acres of barley and peas, and, according to the manner of Indians, we manured our ground with herrings, or rather shads, which we have in great abundance and take with great ease at our doors. Our corn did prove well, and God be praised, we had a good increase of Indian corn, and our barley indifferent good."* * * *

Again, in Edward Johnson's "Wonder-working Providence of Sion's Saviour in New England, Being a Relation of the firste planting in New England in the yeere 1628, London, 1654," written in 1652, the author says: "But the Lord is pleased to provide for them [the colonists] great store of fish in the spring-time, especially alewives, about the bignesse of a herring. Many thousands of these they used to put under their Indian corne, which they plant in Hills five foot asunder; and assuredly when the Lord created this corne, hee had a speciall eye to supply these his peoples wants with it, for ordinarily five or six grains doth produce six hundred."†

Use at the beginning of the present century and later.

269. Menhaden do not appear to have been much used by agriculturists of Cape Cod in the beginning of this century, though the old record shows that the horse-shoe crab and sea-weed were extensively applied.

In 1792 the Hon. Ezra L'Hommedieu, of New York, published a paper in the New York Agricultural Transactions‡ which gives somewhat more accurate data and directions concerning the use of fish as a fertilizer. He says: "Experiments made by using the fish called menhaden or mosbankers as a manure have succeeded beyond all expectation. * * * In dunging corn in the holes, put two in a hill on any kind of soil where corn will grow, and you will have a good crop." He recommends them as a top-dressing for grass. "Put them on a piece of poor loamy land, at the distance of fifteen inches from each other, * * * and by their putrefaction they so enrich the land that you may mow about two tons per acre." But he adds, very wisely, "how long this manure will last has not yet been determined." He gives, in his quaintly interesting way, an account of "an experiment made the last summer by one of my near neighbors, Mr. Tuthill, in raising vegetables with this fish manure," which is worth citing as an illustration of the curious combinations of truth and error, which, in their lack of definite knowledge of the laws of plant-growth and the action of manures, the theorizers of that time invented.

* Coll. Mass. Hist. Soc., 2d series, IX, 1832, p. 60.

† Coll. Mass. Hist. Soc., 2d series, III, 1816, 158.

‡ See Appendix O.

"About the first of June he [Mr. Tuthill] carted near half an ox-cart load of those fish on twenty feet square of poor, light land, being loam mixed with sand. The fish he spread as equally as he could by throwing them out of the cart; being exposed to the weather, they were soon consumed. He then raked off the bones, to prevent their hurting the feet of the children who might go into the garden, and ploughed up the piece and planted it with cucumbers and a few cabbages. The season was extremely dry, and but few cucumbers grew in the neighborhood except what grew on this small piece, and here the production exceeded anything that had before been known. By his own computation and that of his neighbors, this twenty feet square of ground produced more than forty bushels of cucumbers, besides some fine cabbages. I measured the ground myself, and have no doubt of the quantity adjudged to have grown on the same."

Mr. L'Hommedieu's theoretical explanation of this is clear and simple. The fish "enrich the land by their putrefaction." When this process has ceased he questions whether much more good can be expected from them, and doubts if they will make a lasting manure; nor does he find any fault with his neighbor for raking away the bones instead of covering them with earth to prevent their pricking his children's bare feet. In the decomposition a good deal of "effluvia" is evolved, which is evidently absorbed by the leaves of the plants, and contributes to their growth. But "by putting these fish on the land for manure, exposed to the air until they are consumed, there can be no doubt that a considerable part of the manure is lost by the effluvia which passes off the putrefied substance, as is evident from the next experiment." This was made by "Mr. Joseph Glover, a farmer in Suffolk County," who had evidently learned the art of composting fish with earth, and practiced it in a way which some farmers nowadays might improve their ways by imitating.

"He first carts earth and makes a bed of such circumference as will admit of being nine inches thick; he then puts on one load of fish, then covers this load with four loads of common earth, but if he can get rich dirt he covers it with six loads, and in that manner makes of fish and earth a heap of about thirty loads. The whole mass soon becomes impregnated and turns black. By experience he finds that fifteen ox-cart loads of this manure is a sufficient dressing for one acre of his poor land, which produces him thirty bushels of the best wheat by the acre."

Now it happened that Mr. Glover made a heap of fish and earth "in the manner above related near a fence where a field of wheat was growing on the opposite side. The wheat near the heap soon changed its colour, grew luxuriant, and at harvest yielded near double the quantity to the other parts of the field." The improvement in the wheat near the heap, Mr. L'Hommedieu thinks, must be due to the "effluvia arising from the putrefaction of the fish and absorbed by the leaves of the wheat."

President Dwight, of Yale College, visiting Eastern Long Island in 1804, speaks with much approval of the menhaden as a fertilizer, and thus describes the introduction of its use:

"Their agriculture has, within a few years, been greatly improved. For a considerable period before the date of this journey the land had become generally impoverished by a careless husbandry, in which the soil was only exhausted, and no attempts were made to renew its strength. * * * Within this period the inhabitants, with a laudable spirit of enterprise, have set themselves to collect manure wherever it could be found. Not content with what they could make and find on their own farms and shores, they have sent their vessels up the Hudson and loaded them with the residuum of potash manufactories, gleaned the streets of New York, and have imported various kinds of manure from New Haven, New London, and even from Hartford. In addition to all this, they have swept the Sound, and covered their fields with the immense shoals of white-fish with which, in the beginning of summer, its waters are replenished. No manure is so cheap as this, where the fish abound; none is so rich, and few are so lasting. Its effects on vegetation are prodigious. Lands which heretofore have scarcely yielded ten bushels of wheat by the acre, are said, when dressed with white-fish, to have yielded forty. The number caught is almost incredible. It is here said, and that by persons of very fair reputation, that 150,000 have been taken at a single draught. Such, upon the whole, have been their numbers, and such the ease with which they have been obtained, that lands in the neighborhood of productive fisheries are declared to have risen, within a few years, to three, four, and, in some cases, to six times their former value." *

Elsewhere he speaks with equal favor of its use in Connecticut, remarking that it is remarkably favorable to vegetation of every kind, which is the object either of agriculture or horticulture:

"Within the last twenty years the inhabitants of this [Branford] and other townships along the coast have employed for the purposes of manure the white-fish, a species of herring remarkably fat and so full of bones that it cannot conveniently be eaten. In the months of June and July these fish frequent the Sound in shoals, and are caught with seines in immense multitudes. Ten thousand are considered as a rich dressing for an acre. No manure fertilizes ground in an equal degree; and none seems more universally favorable to the productions of the climate. Wheat, particularly, grows under its influence in the most prolific manner, and is peculiarly safe from blasting.

* * * * * * *

"The following is a strong instance of the fertility of land manured with white-fish: Mr. David Dibble, of Killingworth, from 5½ acres of land dressed with this manure, had in the year 1812, 244½ bushels of rye,

* Dwight's Travels, III, 1822, p. 305. Journey to Long Island, 1804, Letter II.

almost 45 bushels to an acre; the most exuberant crop of this grain which I have known in New England." *

In 1819, Rev. D. D. Field spoke of the use of fish as manure as follows:

"The most efficacious manure in the vicinity of the Sound consists of the white-fish which visit the shores in numerous numbers in June and the first part of July. These began to be used for manure in Middlesex in 1801 and 1802. They are carried as soon as taken and spread upon the land and plowed in; or are thrown into heaps, mixed and covered with earth or turf and suffered to pulverize; and are then spread upon the ground as suits the convenience of the farmers. In either mode the effect even on dry and poor land is wonderful, and though it was at first apprehended by many that after two or three crops they would leave the land poorer than they found it, experience has hitherto proved this apprehension to be groundless.

* * * * * * *

"Eight thousand are requisite to dress an acre. They have been sold lately for a dollar and a half per thousand." †

Dr. DeKay in the Natural History of New York, 1842, says:

"The use of this fish as a manure is well known in the counties of Suffolk, Kings and Queens, where it is a source of great wealth to the farmer who lives upon the sea coast. They are used in various ways: For Indian corn, two or three are thrown on a hill; for wheat, they are thrown broadcast on the field and plowed under, although it is not uncommon to put them in layers alternately with common mold, and when decomposed spread it like any other compost. Its effects in renovating old grass fields, when spread over with these fish at the rate of about two thousand to the acre, are very remarkable."

In 1853, Mr. Ker B. Hamilton, governor of Newfoundland, in a "Dispatch to the Duke of Newcastle" on "the Refuse of the Cod Fishery of Newfoundland as convertible into a Portable Manure," says:

"In this island the manure universally applied to the soil is fish, consisting of the superabundant herrings and caplins in the process of decomposition, and generally without any earthy admixture; and the heads, bones, and entrails of codfish, after having been decomposed and formed into a compost with clay or peat-bog earth. This manure * * * when applied to the thin, gravelly, unpromising soil (on the Island of Newfoundland) yields crops of grass and potatoes which, in growth and productiveness cannot be surpassed elsewhere." ‡

Messrs. Boardman and Atkins, in their excellent report on "The Menhaden and Herring Fisheries of Maine," § to which we shall have frequent

---

* Dwight's Travels, III, 1822, p. 513, 514, 516.

† A | Statistical Account | of the | County of Middlesex, | in | Connecticut. | = | By David D. Field. | = | Published by the Connecticut Academy of Arts and Sciences, | Middletown, Conn. | Printed by Clark & Lyman. | .... | April, 1819. 8 vo, p. 153.

‡ Jour. Roy. Ag. Soc., 1st ser., XIV, 1853, p. 393.

§ Agriculture of Maine, 1875-6, page 1.

occasion to refer, say: "More than thirty years ago, before fish oil had become a marketable commodity, the farmers of our eastern coast [Maine] were in the habit of using the fish whole in different forms. In some cases, two or three fish were put in a hill for corn, and covered before the corn was planted; in others they were covered by being thrown into the furrow as the land was being plowed, while in instances less frequent they were made into a compost and applied as a top-dressing. These were the ruder forms of using fish as a fertilizer, and generally practiced before the manufacture of oil and the consequent accumulation of fish scrap."

A method similar to the above was formerly in use among the farmers of New Jersey. Prof. George H. Cook, in his report on the geology of that State, says the practice there was to plow a furrow alongside the rows of corn, deposit the fish, and then turn the furrow back again, covering them. In this way the farmers carried their corn through to maturity, and good crops were gathered from the poorest and lightest soils in the State. A Massachusetts correspondent of the "Country Gentleman" (vol. 5, page 152) says the application of fish compost "appears to ameliorate the effects of drouth."

Use at the present day.

270. Mr. Goode states: "even at this day the fish are often applied to the soil in a crude state, though the manufactured fertilizers are superseding it in most localities. Gov. Caleb Lyon tells me that two or three times every summer Staten Island is visited by smacks loaded with menhaden, which are quickly bought up by the farmers. In planting corn, they put two or three fish in each hill, and so with potatoes; when they plant potatoes in rows, a continuous line of menhaden is placed in the bottom of the furrow, head to tail. In 1871, according to Mr. J. M. K. Southwick, many menhaden were sold for manure in Rhode Island at 30 cents a barrel. During the five years previous he had sold about 75 barrels for this purpose."

Until very lately it has been, certainly, and for aught I know is still, the custom of farmers on the Connecticut coast to use whole fish as a top-dressing.

48. Fish scrap as manure.

The inception of its use.—Experience in Maine.

271. As a result of the profitable utilization of fish for the manufacture of oil, the use of the whole fish as a fertilizer has gradually and almost entirely ceased, and given place to the refuse from which the oil has been expressed or otherwise extracted. This is known in its crude state as "fish scrap," "fish pomace," or "chum," and when more carefully prepared, as "dry fish," "dry ground fish," and "fish guano." Still farmers have been slow to avail themselves of this more concentrated material. Messrs. Boardman and Atkins, in the report referred to, say:

"Its use in Maine even in this way, notwithstanding the results were almost always satisfactory, except in some instances where it was used in too large quantities, did not seem to extend to any great extent back into the interior; and even along the coast where farmers could get the scrap for the hauling, not half of them made any use of it. When the business of extracting oil from menhaden was first engaged in along the coast of Hancock County, and especially in Union River Bay, the works were situated on shipboard, and the scrap was thrown overboard into the bay. The result of this was to drive out all the deep-water fish, as mackerel, cod, &c., and this was continued for many years. On the first establishment of oil works at Bluehill Falls and other places the scrap was given away, and farmers could get a scow-load any time they wished. It is said that the farmers in the town of Brooklin first utilized the scrap by applying it to the land, and during days when no catch of menhaden would give work at the factories, the men would cart the scrap away and spread it as a top dressing on grass lands. It was used green from the press, and on the sandy soil of that town its good effects were most marked. Afterwards, it began to be composted with muck or with fine loam, and was applied to potatoes and grass with excellent results. As a top dressing to mowing fields it was spread on after haying, and in this way was generally used fresh. Too large an application was found to induce too rapid a growth of grass and to cause it to rust, and it also gave a fishy flavor to the hay, not relished by cattle; but these matters were gradually learned from experience in its use, and as gradually mastered and overcome. As its value became known its price advanced, and for several years, from about 1858 to 1864, it went up to $6.00 per ton."

Experience in Connecticut.—Mr. Clift.

272. At a meeting of the Connecticut Board of Agriculture in December, 1873, Rev. Wm. Clift, of Mystic Bridge, gave a lecture on "Marine Manures."* This was followed by a discussion, in which a number of the best farmers of the State took part, and is interesting, as showing what the practical experience of men who have used fish scrap as rationally as intelligent farmers do anywhere, says of its uses and value. Mr. Clift said:

"Along the shores [of the Long Island Sound] where I have lived for the last twenty-five or thirty years, very large quantities of white-fish, or menhaden, are taken for the purpose of making oil. Formerly they were taken simply for the purpose of making manures, and were caught in very large quantities all along our shore and over on Long Island, in large seines, which were generally owned by companies composed of farmers. These fish were carted by the farmers quite long distances, spread broadcast over their fields, and left to putrefy in the open air, and then along in the fall they would be plowed in for rye and for other

* Report of Conn. Board of Agriculture, 1873, p. 197.

crops. This, of course, was a very wasteful process, as a large part of the ammonia which the decaying fish furnished went off into the air; still, it was a very valuable manure used even in that way. Not only were white-fish taken, but very large quantities of sharks, and some valuable food-fishes were oftentimes taken in connection with these fish, which were caught expressly for manure. Latterly the oil has become exceedingly valuable, so that the companies now take the fish for the purpose of procuring the oil, and the refuse, what remains after the oil has been expressed, is sold for manure. I suppose about forty millions of white-fish are taken annually along the shore of Fisher's Island, in the sound, between New London and Stonington, a distance of not more than ten miles, probably, and there are some six or eight companies that have been organized for the purpose of taking these fish. These companies are quite prosperous, and a source of quite large income, not only to those who are engaged in fishing, but to other people. They make a market for the wood of the farmers in all that region. It is quite a common thing for the farmers to exchange their wood for this fish scrap. About two cords of wood, delivered on the shore, will buy a ton of this fish scrap. * * * Sometimes they get it in season for the farm [spring?] crops or turnips, and always in season for the rye crop in the fall. The price is from $13 to $16 per ton. * * * A great deal of it goes up the Connecticut River. The tobacco raisers know the value of fish scrap, and it is sent quite a distance into the country. * * * The farmers all along the coast use the fish scrap in what is called a 'fish pie.' The scrap is drawn to the farm, a few furrows are turned up near where they want to use the fish scrap the next year, a layer of scrap is put over these furrows, then a layer of sods and so on, forming a compost heap four or five feet high. Probably eight or ten times as much earth as scrap is used, in bulk or weight. After it has lain a few weeks in this condition, it is forked or shoveled over, so that it is all intimately mixed, and the scrap very nearly absorbed by the soil, and in that condition it is fit either to be spread upon the ground for rye or for corn crop the next season. It is also used in connection with stable manure. The scrap is carted into the yard where the stable and yard manure is heaped up, and mixed with that; it adds very greatly to the value of yard manure. They will put, perhaps, one ton of the scrap to ten tons or more of yard manure; and then, after it has remained two or three weeks, it is carted off for top-dressing for corn or potatoes, or the ordinary crops of the farm. I have used fish scrap for the last three years on the rye crop, and find it exceedingly beneficial and economical. The soil where I use it is a gravelly loam, very well underdrained, but it has been pretty well exhausted by long cropping. I spread about half a ton of this manure to the acre, and get a very satisfactory yield of rye from this light dressing. It costs me about seven or eight dollars an acre for the manure, and I get in return for it about fifteen bushels of rye to the acre, and

nearly a ton of straw. The straw sells with us for about twenty dollars a ton, and rye is worth from ninety cents to a dollar a bushel; so that for a very small expenditure for manure I get very satisfactory crops of rye. * * * A year ago last summer I used a ton of fish scrap on half an acre of land. It was nothing but gravel. There was hardly any vegetable matter; none but what had grown out of the gravel, and, perhaps, a little washed from the surrounding land. I did not pay anything for the land; the owner did not consider it worth anything. I got a glorious crop of corn, cabbages, and potatoes on that little piece of land, by the use of a ton of fish scrap."

With regard to the value of green and dried scrap and the loss in drying, Mr. Clift says:

"As it comes from the press, after all the oil has been pressed out of it that can be gotten out by the strongest hydraulic pressure, there is still a great deal of moisture in it—40 or 50 per cent. As it lies on the platform under cover, there is, of course, a constant loss of moisture, but there is also a loss of ammonia, which is very valuable, so that I am not able to say whether the fish-scrap is any more valuable after it has lain a month or two in the house than when it first comes from the press. I think I should prefer to take it as it comes from the press. I think the ammonia which is lost is worth more than will be gained by the evaporation of the water. Fish-scrap, at $12 to $15 per ton, is the cheapest manure we can buy. It is the only commercial fertilizer I have bought for the last six or eight years. I do not invest in superphosphates or bone-dust. I would invest in the latter if I could get a pure article, but when it is half plaster of Paris I do not know what I am buying. But this article, when it comes from the factory, is generally fish scrap and nothing else. It always produces just about the same result. You can depend upon it. If you apply one or two tons to the acre, you know what you will gain by its use if it is properly put into the soil and you have a fair season. I think it is a perfectly secure investment for the farmer to make."

Experience of Mr. Hall and Mr. Loveland.

273. Some of the discussion which followed is worthy of note. Mr. Hall, of Wallingford, remarked:

"My experience in regard to fish-scrap is that when it comes from the press it is about 65 per cent. water. Now if that is worth $12 to $15 a ton to carry back ten or twenty miles into the country, when you come to add the freight and the inconvenience of handling it to the freight, I should consider the dried the cheapest. I have used a great many tons myself, and I have always used the dry as the most economical. I have been so situated I could have either, but I preferred the dry; and as Mr. Clift has said, by analysis, it was a cheap manure at the prices at which it was sold." Mr. Clift replied: "Mr. Hall means a different thing by dried fish guano, from what some gentlemen do by 'dried fish.' He

means the article spread upon a platform, and made as dry as it can be in that way. What is termed 'dried fish' is another thing. It will take from two to two and a half tons of fresh fish to make a ton of dry, and after that has lain in a tight building for some time, it will take two tons of that to make a ton of the dry guano. When the green manure is spread out and immediately dried in the sun, there is no loss of ammonia, but when it is kept in a pile, of course putrefaction begins, and as it advances there is loss of ammonia. There is no considerable loss of ammonia by drying in the sun and of course the dry manure, finely ground, is very much more valuable than that which is dried in a heap where there is a great loss of ammonia."

Mr. Loveland said of his experience with fish-scrap:

"I would say that I have had considerable experience with fish-scrap, having used it for the last eight or ten years. I bought it as it is prepared by the companies at Milford, where it is produced as a superphosphate, and sold at the rate of $45 a ton. I have used it with Bradley's superphosphate, with Coe's and with Wilson's on tobacco and other crops, and wherever I have used it in connection with these high-priced manures, I have found that the fish manure was fully equal to them; it bore up its crop as well as any of the commercial fertilizers in the market. I have bought it in the green state mostly, in bags and barrels, and it has cost me about $23 a ton to get it up to the north part of the State. I have not used this fish-scrap much by spreading it upon lands in its raw state, nor by putting it into the hill, as they do in Lyme, and on the coast, in raising potatoes and the like. I have seen some instances in our town where it has been spread upon the ground in a raw state, and then the tobacco set, and the effect has been to stop the growth of the tobacco. It has been too powerful in that condition for the tobacco to grow upon it; and where it has been used in that way, I have never seen half a crop of tobacco. My method has been to compost it, invariably, and I believe that is the true method of using such a fertilizer as that. It is a fertilizer having all the elements of an organized body. It contains all of the fish that we desire; the oil that has been taken out we hold to be of no use in agriculture. Coming to us in the green state from the factory, it has not lost any of its ammonia to speak of, and in that state it must be a perfect manure, because there is no adulteration in it. In composting it, I have used muck, treated with lime and salt—about four cart-loads of muck to four or five hundred pounds of the fish, building up a large pile of it, in that proportion, which, after a while, begins to heat, and the whole mass is leavened and brought into oneness of condition. The fish-scrap fertilizes the whole mass with its elements, and it may then be spread upon natural grass-land or cultivated ground, and will invariably produce a very fine crop. It never has failed with me to produce a good crop, and where I have manured grounds in that way and seeded them down, I have got good crops of grass for years in succession afterwards."

Statements by Professor Cook, of New Jersey.

274. Prof. G. H. Cook, of New Jersey, in his report as secretary of the State Board of Agriculture, writes:*

"The supply of material for fish guano is almost unlimited in this State, and it only needs capital and skill to build up a business of great importance to the State and profit to the manufacturer. On the coasts of Long Island and of Maine, where the business has been carried on for the oil which could be got from the fish, the residuum has been sold at various prices, from $15 to $30 a ton, and has been a very popular fertilizer with those who have used it. It is sought for by the manufacturers of superphosphate of lime, to mix with their product, and there can be no doubt that it is very beneficial in such a mixture, giving quickness to its action, while the superphosphate would add to the duration of efficiency. When this source of manure is properly worked, it can be made to supply all the guano needed in the State."

Professor Cook says, also:†

"While the most common mode of using these fish is in the hill or furrow for corn, they are often employed in a compost with barn-yard manure and a little lime. *Those who have tried such a mixture say that it is superior to any guano in the market.* When applied on corn the crop is considered as certain. Some farmers mix them with muck and apply the compost upon wheat. This fertilizer is wonderfully rapid in its effects, showing changes in the growth of a crop in a few days after it has been applied. But it is not a lasting manure. In a year or two this stimulating effect is gone, and a second application is necessary. For producing quick results it is so efficient that all farmers who have tried it unite in testifying to its value."

Further experience in Maine.—Messrs. Hinkley, Kenniston, Smith, and Collins.

275. On pages 47 to 55 of the report of Messrs. Boardman and Atkins, referred to, are some "Practical Notes on the Use of Fish Scrap as a Fertilizer," which contain a number of items of experience of Maine farmers worth quoting:

"Hon. J. T. Hinkley of Bluehill, in a private letter, writes: 'I have never used but it in one way. I mix it with fine dirt or sand, and use it as a top dressing on grass-land. A dressing of one ton of chum mixed with five times that amount of dirt is about the quantity I would put on one-half acre of land, and from that I have a good crop of grass for four to five years without injury to the land. * * * There is an objection here to dressing too heavily with scrap, as it injures the quality of the hay; but using it at the rate of one ton to the acre, in a compost of three parts loam, will produce no effects of this nature.' Now to correct the error

* First Annual Report of the New Jersey State Board of Agriculture, 1874, page 44.

† Geology of New Jersey, 1868, p. 498.

into which a good many farmers are led by statements that the application of fish-scrap, or other active special manures, like guano or superphosphate, damaged the land, rendering it unproductive and sterile; it may be stated here that the real cause of this sterility does not come from the application of these so-called *forcing* manures which are applied to the land, but from the taking off of the large crops which follow their application. They exhaust the soil by drawing from it elements which the manure put on does not contain, and which repeated applications of the same fertilizer would not supply; it is in fact the crop taken off, not the manure put on, which injures the land. But it must also be remembered that after land has been brought up to a condition of productive capacity by the use of fish-scrap or special fertilizers, it can be kept so only by the application of stable and barn-yard manure, or the manure made by consuming the hay grown upon the soil thus improved. This should invariably and in all cases be given back to the land, or the time will speedily come when it will refuse to 'discount.'"

"Mr. William Kenniston, of North Boothbay, furnishes some interesting statements regarding the use of scrap upon his farm. He has used it more or less for the past eight or ten years, and says he 'could not farm without it.' He hauls it from the factory generally late in the fall, as it is dryer then and less objectionable to handle, and composts it with yard and stable manure, muck, and loam. When one year old this is hauled out and spread, in the fall or winter, wherever it is most convenient to do so, at the rate of about eight cart-loads to the acre. In using the scrap without being composted, as he has sometimes done, he regards one ton of well-dried scrap better than three just as it comes from the press. The dry scrap is much easier and better to handle, and may be used on grass at the rate of three tons to the acre; but the raw scrap from the press should invariably be composted. In 1867 he used five tons of scrap mostly in a green state. It killed the corn, the grain lodged and was damaged, and grass has lodged on the piece ever since, although no manure has been applied since. He had spread it on grass fields both in the spring and fall, but preferred the latter. Mr. Kenniston believes if the scrap was packed in barrels just as it came from the press it would stand transportation by steamer or rail to almost any part of the interior of Maine without becoming offensive.

"The farmers in Machias purchase herring chum from Lubec, whence it is brought in small schooners. It is usually packed in barrels of from 220 to 280 pounds each, at $11.50 per ton, but is not used in very large quantity. Lobster chum, from the canning factories at Englishman's River, is also made use of to some extent as a top-dressing. It is obtained in scows and boats at about $4.50 per ton, delivered in Machias and vicinity. One ton of it is composted with ten loads of common loam, and this amount spread upon an acre. Applied to grass land in the fall, the results are most satisfactory."

"Mr. H. T. Smith, of Machias, has perhaps made a larger use of fish-scrap, as a fertilizer, in different ways, than any farmer in that place or vicinity. His usual practice is to obtain the scrap (generally herring scrap) in the fall, and apply it in the spring. When grass land is in fair condition he uses about one-fourth of a ton per acre, and never more than one and one-fourth ton per acre. It is, of course, less expensive to apply it directly to the land as it comes from the press, but it is often composted, using three parts of earth to one of scrap. For grain, Mr. Smith has plowed under seven hundred pounds to the acre, from which he has grown very heavy crops of barley, oats, and wheat. Mr. Smith says: 'I have paid $80 per ton for superphosphate, and if given my choice had rather have one ton of fish scrap than one ton of superphosphate. If barrelled as soon as it comes from the press (he is speaking of herring scrap, which, it will be remembered, is treated with salt before being pressed), it has no unpleasant odor, and is not offensive to handle. There is nothing equal to it for the land. It is as valuable as night-soil, and is good for grass, grains, corn, garden crops, anything that grows out of the earth.'"

"Capt. Jason Collins, of the steamer 'Star of the East,' thus relates, in a private letter, his experience in the use of fish scrap as a fertilizer: 'My experience in the use of fish chum does not reach over many years, but I have applied it to barley and on grass. The amount used per acre for barley was 1,500 pounds, which was mixed with two parts loam to one of chum. This was spread on and harrowed in. In the fall of 1873, I had five acres plowed up, on which I put 2,000 pounds to the acre. It was harrowed and rolled in the fall, and the following spring, about the last of March, I think, it was sown to grass-seed alone. The grass was cut the last of August, and it was very heavy. I have also used it for turnips and potatoes, and it has done well for each crop. In the fall of 1873 I also had chum spread on some six acres of grass land, as a top dressing, at the rate of three-fourths of a ton per acre, mixed with loam in the same proportions as that used for barley. It did first-rate. This fall (1874) I shall use more, which I shall compost and lay over until another fall, as in that form it will be better about handling. From all I can learn, and from my own experience, I am satisfied that late fall is the best time of the year to apply it as a top-dressing for grass lands; and the amount should be from three-fourths of a ton to a ton per acre. It is best if used as a compost, as I have stated. For hoed crops it must be used very carefully, and should in all cases be thoroughly composted. In regard to its price, it cost me $12 per ton green, in bulk, and have had it brought from Boothbay to Gardiner in lighters. When in barrels it costs $15 per ton, but it is cheap at that price, and I shall buy no other fertilizer until I find something better for less money. At $12 per ton it is cheaper than it is to haul stable-manure, even if the manure is given to you. Perhaps I have not used it long enough to speak of its effects upon the land, but during my experience with it I have witnessed

no ill effects, although if used in too great quantities the grain will grow rank and lodge. I can hardly yet tell what it will do in a long run, but am satisfied with it after a five years' trial.'"

Other testimony.

276. "Numerous testimonials similar to the above could be given from correspondents and from agricultural reports and journals, but enough has been stated * * to show the great value of fish scrap as a fertilizer when composted or judiciously applied in connection with animal manure. Remark: Too much stress can hardly be put upon this qualification in regard to its use. An instance is mentioned in a former volume of this report* of a farmer who first began to use the scrap; composted it in the fall with three times its quantity of earth. The next spring the mixture had so much the appearance of common earth, and the party had so little faith in its efficacy, that a shovelful to the hill was applied for corn. It came up well, grew for a time looking green and thrifty, but soon began to grow pale, finally died, and the crop was a failure. But the effect of this application was noticeable for many years afterwards, and even with no other application of manures of any kind the land continued to bear an immense burden of grass. In the discussion to which reference has been made, before the Connecticut Board of Agriculture, Mr. Fowler, of Guilford, gave a word of caution which he thought should be exercised in the application of fish scrap. He said: 'My experience has satisfied me it will not answer to use fish alone as a fertilizer for a term of years. It forces the crop and finally leaves the land in very bad condition, very hard and sterile, and it will usually show a pretty heavy crop of sorrel after harvest. But if it is used as it should be invariably, in connection with stable or barn-yard manure, it is perfectly safe to use every year for a term of years for any crop.'"

49. The manufacture of fish manures.

Early attempt at manufacture.

277. The first attempt to manufacture a portable manure from fish is said to have been made by Mr. Lewis, at New Haven, Conn., in 1849.† The white fish, or menhaden (*Brevoortia tyrannus*), was employed, and after a good deal of experimenting a manure produced which contained, according to analyses by Professor Norton, as high as 10.23 per cent. of nitrogen. The enterprise was, however, for some cause, discontinued.

The De Molon process.

278. The next effort in this direction seems to have been in 1851 or 1852, by De Molon, a Frenchman, who, in company with other parties, is

* Hon. S. L. Goodale, Agriculture and Geology of Maine, 1861, page 49.

† See communication by Prof. S. W. Johnson to the Country Gentleman, July 1857, and article on Marine Manures, by S. L. Goodale, Agriculture and Geology of Maine, 1861, pp. 50–56.

said to have put up a manufactory at Concarneau, in the department of Finisterre, for the manufacture of guano from the refuse of the sardine fishery, and one on the coast of Newfoundland, at Quirpon, near the eastern entrance of the Strait of Belle Isle, for the utilization in similar manner of the refuse from the cod fishery. According to the *Chemie Industrielle*, the establishment at Concarneau, in 1854, employed sixteen operatives and worked up daily eighteen or twenty tons of refuse into four or five tons of manure. The composition of this article is noted by Payen at 11.6 per cent. of nitrogen and 10.3 per cent. of phosphoric acid, with only 2.5 per cent of fat. Other analyses gave about 12 per cent. of nitrogen and 6.7 per cent. of phosphoric acid. The Quirpon establishment was reported as able to produce 8,000 or 10,000 tons of manure annually.

A manufactory of fish guano by the De Molon process was reported as in operation at Lowestoft, in England, in 1856. The same process was said to be employed in 1857–1861, by the Oceanic Oil and Guano Company at Southold, Long Island, N. Y. A pamphlet put out by this company describes the process as follows:

"The raw fish, in quantities of one and two-third tons (or about 5,000 fish), are placed in the inner chamber of a revolving cylinder, the vacuum between the inner and outer chamber being heated by steam at about 80 pounds pressure. Before letting in the steam the cylinder must be put in motion, so that each fish, as the cylinder revolves, is constantly changing its position. The cooking at this pressure of steam requires but ten minutes, during which time a uniform temperature is maintained by means of one head of the inner cylinder being perforated so as to allow the escape of the steam generated from the water contained in the fish, which prevents the dissolution of the gelatine and all the soluble parts, and they are therefore retained in the fish. When the heat in the inner cylinder has arrived at the temperature to produce steam from the fish, it escapes through the perforated head, and thus enables the fish to receive a temperature just sufficient to open the cellular tissues and give an easy and speedy egress to the oil.

"After the fish are thus steamed, they are put into strong bags, prepared in size to fit the top of the press-head, in layers of eight inches of thickness; between each layer or bag is placed a strong iron plate. In this manner the press is filled, when they are subjected for about five minutes to a powerful hydraulic pressure. After the oil has ceased to run, the remains are then put through a strong picker, which reduces the cakes to small particles for the drying process. It is then dried by heated air or by platforms exposed to the sun."

Early manufacture in Rhode Island.

279. Prof. Charles T. Jackson, writing in 1854, remarks:

"In this country a company has been formed, in Rhode Island, for the manufacture of fish manure, and the fat menhaden of Providence River

and Long Island Sound will be used to produce both oil and fish-cake, and the latter, being duly prepared so as to render it inodorous, will be sent into the agricultural market as an artificial guano. I have no doubt of the high fertilizing effects which this guano is capable of producing, nor of the economy of the manufacture proposed."*

Manufacture in Canada.

280. Mr. Hunt, in the Report of the Geological Survey of Canada, under date of March, 1858, says:

"Mr. Duncan Bruce has lately been endeavoring to introduce the manufacture of fish-manure into Canada; but he conceived the idea of combining the fish offal with a large amount of calcined shale, under the impression that the manure thus prepared will have the effect of driving away insects from the plants to which it is applied." * * * Analyses of this manure, by Mr. Hunt, showed it to contain about 3 per cent. of ammonia and something more than 3 per cent. of phosphoric acid; and so of less than half the manurial value of a well-made article from pure fish alone.

Manufacture of "cancerine" in New Jersey.

281. Professor Cook, State geologist of New Jersey, in his report for 1856, states that—

"An establishment for making a concentrated manure from king-crabs or horse-feet had been erected at Goshen, in Cape May County, by Messrs. Ingham & Beesley. Several hundred tons of this substance were made last year and sold under the name of *cancerine*. It is a powerful fertilizer, and in its composition, as well as in its effects, has considerable resemblance to guano." The average per cent. of ammonia and phosphoric acid in "cancerine," as shown by three analyses by Professor Cook, was 9.92 per cent. of ammonia and 4.05 per cent. of phosphoric acid, and he estimates its value at $31 per ton; and further says, "the results of trials with it have fully sustained its value as determined by analyses."

Early manufacture in Maine.

282. Mr. Goodale says further, in the report referred to:

"Until within a few months, I was not aware that any attempt had been made in our State to manufacture a portable manure from fish; but I have recently learned of several. In Boston I found an article for sale under the name of 'fish-guano,' which by inquiry was ascertained to have been made by a Mr. Fowler, at Lubec. I learned subsequently that he had manufactured a quantity two or three years previously, but that either from not finding a ready sale, or from other causes, had discontinued its manufacture. It is understood to have

* Report of the Commissioner of Patents for the year 1854—Agriculture.—Washington * * * 1855, p. 107.

been made by drying the fish after pressure, when it was ground and a portion of gypsum mixed with it. As offered for sale, it was a grayish powder, in which portions of bone could be distinguished.

"Learning that a somewhat similar article had been sold and used in some of the Penobscot towns, from Mr. C. G. Alden, of Camden, I called upon him, and found that he had made last year, for the first time, about a hundred barrels, at Long Island, in Blue Hill Bay, which he sold readily at $1.50 per barrel of about 150 pounds, and learned that it gave entire satisfaction. It was prepared from pogy chum by simply drying it in the sun, and when packed he added a peck of gypsum to each barrel. Some barrels were examined which had just been made (August, 1861), and the article appeared to be in a good state of preservation, except that it was slightly moist and gave off free ammonia. Mr. Alden intimated that the lack of sufficient capital alone prevented his entering into its manufacture upon a much more extended scale. He hoped, however, to prepare five hundred barrels or more the present season.

"At Eastport I found fish guano manufactured upon a larger scale. Messrs. U. S. Treat & Son, well known for their enterprise, perseverance, and success in the artificial propagation of fish, after preliminary trials for some years past, prepared about one hundred and fifty tons during the season of 1860, nearly the whole of which was shipped to Connecticut. He makes it under a patent held or claimed by the Quinnipiac Company of Connecticut. It is manufactured almost entirely from herrings, of which they formerly cured a large amount, but now find it more profitable to make it into guano. They are caught in weirs (about Treat's Island, on which they reside), and are thence taken to a railway running into the water and dipped into a car, drawn up by a windlass. When the car comes to be opposite one of a tier of tanks near the track, a gate or door in the car is opened and the fish slide in; salt is added in the proportion of one bushel to each hogshead (of four barrels) of fish. After pickling for about twenty-four hours, they are moderately heated in open kettles, when they are pressed to obtain the oil, of which they yield about 8 per cent., and to express as much of the water as possible; after which the cake or chum is broken up, spread on a platform of boards, and dried in the sun. It is subsequently ground and packed in bags of two bushels each, and which contain eighty pounds—twenty-five bags or about fifty bushels to the ton of two thousand pounds. He sells it for $15 per ton; and the cost of the bags, delivering or shipping, are extra charges.

"The platform in use last year for drying is about eighty by one hundred and twenty feet square, slightly inclined to the sun, with a storehouse on the lower side. Another was in process of erection when I was there, as also another railway and other conveniences for extending their operations.

"The patent held or claimed by the Quinnipiac Company is understood to be 'for drying by solar heat upon an elevated platform.' If a patent be granted for this, why not for drying salted fish upon an elevated flake, or for drying clothes on an elevated line, by solar heat? From various sources, I learn that the fish guano prepared by this method gives high satisfaction.*

"Prof. S. W. Johnson, of Yale College, chemist to the Connecticut State Agricultural Society, informs me that the article prepared by the Quinnipiac Company is the most popular fertilizer sold in that State.

"To sum up in a word the results of my investigations and experiments regarding the manufacture of a portable, inoffensive, and efficient manure from fish or fish offal, I may say that I deem the same practicable; that no costly machinery or complicated processes are required; that all which is necessary is, first, to cook the fish sufficiently to coagulate the albumen contained in it; then to express as much of the oil and water as may be, and to dry the remainder as quickly and thoroughly as possible. A pickling of the fish first with salt would probably facilitate the operation.

"It is confidently hoped that the waste of such enormous quantities of fertilizing material as have hitherto been thrown will not much longer go on, but that they may be converted to use, feed our hungry fields, and fill our barns with plenty."

Early manufacture in France.

283. Turning again to the manufacture of fish manures in Europe, we note that the process of De Molon, referred to above, is described by Deherain (*Wurz Dict.*, ch. I, 1236) as follows: "The fish are first boiled, then pressed to force out the water and oil; the residue is then dried and ground in a mill." De Molon's first factory was at Concarneau, Department of Finisterre. He seems to have established others on the English coast and in Newfoundland, in company with Thurneyssen. From disconnected statements in different works to which I have had access, the industry on the French coast seems to have suffered from lack of material. A company, "Credit Mobilier," into whose hands the enterprise fell, attempted to use city refuse with it, but through business complications, stock speculations, etc., the whole undertaking failed.

About the same time that De Molon introduced his method of manufacture in France, Pettit and Green patented another process in England (1852), the peculiar feature of which was "the use of sulphuric acid, which was added to change its consistence." After treatment with the acid, the fish was dried in hot air.

*According to Mr. Boardman, Mr. C. G. Allen, of Camden, Me., was engaged in 1862 in making fish guano from "pogy chum," by drying it in the sun. (Rept. U. S. Dept. Ag., 1862, p. 57.)

Early manufacture in England.

284. From an article in the "Farmers' Magazine" (London) for August, 1859, by Samuel Osler, of Great Yarmouth, who claims to have discovered a method preferable to that of De Molon or Pettit, a few paragraphs are quoted by Mr. Goodale:

"The enormous consumption of guano, its high price, and extensive adulteration, have led to a desire of an auxiliary or substitute. The most obvious source is the fishery. * * * What we require is a simple, cheap, and effectual mode of separating the parts which are needless for manure—the water, gelatine, and oil, the two latter sufficiently pure to be commercially valuable, and leaving the fiber, bones, and scales in a state fit for keeping and for use. It has been ascertained by experiment, and confirmed by actual working, that the refuse and waste fish may be thus converted, and the gelatine and oil collected by a process which I have discovered. The machinery and the process are simple, inexpensive, and effectual. The principle of the manufacture is founded upon the fact that when fish or flesh is subjected to a long-continued and moderate heat the fluids separate, dissolve the gelatine, and leave the fibrous and bony solids. This is easily shown by putting meat or fish into a flask and setting it in boiling water, corking the flask when fully heated. The fluids will gradually separate, while the flesh will, after a time, be left a dry and insipid residuum."

Mr. Osler gives the results of several analyses by Professors Way and Voelcker and Dr. Stoeckhardt, by an average of which it appears to contain about 12 per cent. ammonia and 7 per cent. of phosphates.

Other European manufacture.

285. In the Paris International Exhibition of 1855, among the specimens of artificial manure was one, "*engrais poisson*," prepared from fish, which, "after being steamed, were pressed into cakes and dried." It was "said to contain from 10 to 12 per cent. of nitrogen, and from 16 to 22 per cent. of phosphate (= 7½ to 10 per cent. phosphoric acid). The price was about $35 per ton.

On the coast of the North Sea, at Varel, in Oldenburg, immense numbers of a kind of small crab (*Crangon vulgaris*), called in German *Granaten*, or *Granälen*, are taken, dried, ground without any steaming, and thus made into what is called "Granat guano."

On the coast of the Baltic Sea, at Labagiehnen, near Labiau, in East Prussia, considerable fish refuse has been manufactured into a fertilizer.

The following are analyses of the articles just named:

	Nitrogen, per cent.	Phosphoric acid, per ct.
Fish guano, Pettit	9.1	7.6
Fish guano, Green, No. I	9.1	1.6
Fish guano, Green, No. II	13.8	0.2
Fish guano, De Molon and Thurneyssen	11.6	10.1
Granat guano	11.2	2.2

These figures are taken from a report by Professor Schmidt, of Dorpat, on the "Artificial fertilizers at the second Baltic agricultural exhibition, June, 1871," who adds that none of the articles seem to have attained enough importance to secure a place in the wholesale market.

The Norwegian fish guano.

286. By far the most important of European fish-waste products, in fact the only one that has been made in large enough quantities to bring it into very general and widespread use, is the Norwegian fish guano, manufactured from the waste of the fisheries on the Lofoden Islands, and elsewhere on the Norwegian coast.

In the Polar Sea, near the 70th parallel, north latitude, off the extremely wild, rough, and dangerous coast of Northern Norway, near the famous and dreaded maelstrom, lies a group of islands, rough, rocky, and precipitous, the peaks of some shrouded in eternal snow, about 40 in number, and bearing the name Lofoden. The neighboring mainland is inhabited by nomadic tribes of Laplanders. The islands have neither four-footed beasts nor food for them to live upon; but the sea about them teems with fish, and the air with sea-fowl. But few human beings are there, except during the fishing season, from February until April, when from 12,000 to 14,000 fishermen come, with 3,000 to 4,000 boats; bring scanty supplies of coarse bread, dried fish, and bacon; live in miserable huts, sleep in sheep-skins; and with lines that have sometimes as many as 3,000 hooks apiece, catch from 18,000,000 to 20,000,000 codfish per annum. These fish are cut up; the sides are dried and sold as "stockfish" all over the world. A part of the residue is used in the northern regions as cattle food. The heads and backs were formerly thrown into the sea or left to rot upon the rocks. Of late years, however, they are gathered, dried upon the rocks by the sun's heat, ground in factories that are scattered about in sheltered bays, and thus made into the Norwegian fish guano. A business circular concerning the Lofoden fishery products says that the cods' heads and backbones are collected mostly by women, children, and infirm persons, who cannot take part in the fishing, dried either on the bare rocks or on poles, and then ground, put in bags of about 2½ cwt., and shipped; the material delivered at Hamburg at the rate of about £9 per (long) ton. The circular adds that "it has been a great benefit to the Lofoden fisheries to get rid of this waste which formerly spoiled the bottoms of the fish banks, and infected the habors, where in some places it used to lie knee-deep upon the beach." Another account states that the gathering of the refuse has already become an important industry for the poor people there.

The earliest notice I have seen of the Norwegian fish guano is by Stoeckhardt* in 1855, who then reported the manufacture as started on

* *Der Chemische Ackersmann*, I, 1855, s. 236. See articles by Stoeckhardt and by Meinert in same journal, I, 1856, s. 118; V, 1859, 44; VI, 1860, 59; IX, 1863, 117; XV, 1869, 43; XVI, 1870, 43 and 53; XVI, 1871, 245; and *Landw, Centralblatt*, 1874, 613; and by Vohl. Dingler's *Polyt. Jour.*, CCXV, 1875, 460.

the Lofoden Island by Dr. Scheibler and Herr Fröhlich. In 1856, Stoeckhardt informs us that a joint stock-company had been formed at Christiana for the manufacture of the guano, and had taken the patent from Dr. K. Hansen and F. C. Schübler. (The Dr. Schiebler above ?) The company consisted of these two gentlemen and three others, Messrs. Fröhlich, Broch, and Heftye. In 1859, he reports the manufacture as having finally begun in the past season (1858) on a large scale. In 1860, the guano was offered for sale in Germany, by Mr. Meinert, of Leipsic. In 1863, Mr. Meinert states that, "unfortunately," the fish guano has become so popular in Norway, Sweden, and Denmark, that a large part of the supply has been retained there, and not enough will reach Germany to supply the demand. In 1869, Meinert reports to the "Ackersmann" that the manufacture has attained such a degree of perfection that an article can be offered of uniform composition, and containing 8 to 10 per cent. of nitrogen and 10 to 15 per cent. of phosphoric acid.

In 1870, it was stated that the refuse of 4 to 5 million codfish was worked up into guano, while that of the remaining 14 to 15 million was still allowed to go to waste.

In 1871, Meinert, whose accounts of his journeys to Lofoden, published in the "Chemische Ackersmann," are well worth the reading, reports the success of attempts, undertaken by himself, to make guano from whole fish, from kinds whose inferior value for human food had caused them to be sold at very low prices or to be used in Norway for cattle food. From these "waste fish" 200 tons of guano had been prepared, of so good quality that a content of 11 to 12 per cent. nitrogen and 5 to 6 per cent. phosphoric acid. The high proportion of nitrogen is due to the use of the whole fish. It finds rapid sales at higher prices than the ordinary guano.

In 1874, the "Landwirthschaftliches Centralblatt" (XXII, 613) speaks of the Norwegian guano as follows:

"The Norwegian guano, as is well known, is made of the heads and backs of the cod.* These fish are taken from January to May, all along the coast from Finmark to Hammerfest, lat. 68–71 N., but especially on the Lofoden Islands. During the season 2,000 fishermen are engaged. The catch of cod has averaged during the past ten years, according to statistical reports, from 18,000,000 to 22,000,000. The sides of the fish are dried either on lines upheld by posts or upon the rocks. Those prepared in the former way are sold in Spain, Italy, &c., under the name stock-fish; the others are sent to Russia and Sweden, under the name of *Klippfisch.*† The refuse was formerly thrown into the sea or left to the sea fowls, except the small quantity used as fodder

---

*The *Dorsch, Gadus callarias,* common Cod, and *Kabeljau, Gadus molva vel morrhua,* Ling, are both said to be taken at Lofoden. Sometimes one and sometimes the other is named as the principal fish of those fisheries. [They are the same. G. B. G.]

†*Stock,* rod, stick; *Klippe,* rock; so cod. Anglo Saxon *gad* or *goad,* a rod, and the Latin *gaudus* has a corresponding Sanscrit root, *cad* or *gad,* a rod. See paper by J. C. Brevoort, on the names of codfish.

for cattle and sheep. The heads (some as large as small calves' heads) and the backs of the cod (*Dorsch*) form the chief raw material for the fish guano. They are dried in the air on the rocks, then torn up by machines, and finally ground to a product resembling coarse bone meal. Since, however, not inconsiderable quantites of cod are also caught along the Norwegian coast southward from Lofoden, as far as Aalesund, the preparation of fish guano has offered the inhabitants a new and useful industry; the demand has increased every year and since the supply has not sufficed even for the German market, a considerable number of larger or smaller factories have sprung up all along the west coast of Norway. Competition soon led to the manufacture of a more finely ground product, and to the utilization of a large portion of the available material for preparation of fish guano. Nevertheless, a good deal of the material was still allowed to go to waste, so that the production of the guano is capable of further development. Recognizing this fact, Dr. A. Meinert, son and business partner of the original German importer, has, in connection with some German merchants, established two new factories in Norway, one in Lofoden, the other in Hammerfest. The former was completed during the past summer (1874). The guano from these establishments is first steamed, then dried and ground to a fine dust, and is consequently very similar in its action to Peruvian guano."

The report adds that, on account of the difficulty of transporting fish guano to Sweden, factories have been put up in that country also, to supply the home demand.

The most remarkable enterprise in this direction is one for the manufacture of guano from whale refuse, on the boundary between Norway and Russia, beyond the North Cape, in the latitude of 70°. It was undertaken in 1870–1873, by Capt. Svend Foyn, who is described as "the greatest whale fisherman of our time." With his fleet of steam and sailing vessels he visits the coast of Greenland in February to catch seal, and thence sails in March to the North Polar sea in pursuit of whales. He captured, in 1869, thirty-two whales and expected to be able, by use of improved vessels and appliances, to take fifty per annum. A whale, according to Captain Foyn, weighs on an average 230,000 pounds (115 tons); each fish furnishes about 80,000 pounds of fat, several hundred pounds of whalebone, and 100,000 pounds raw stock for fish guano. Fifty whales are expected to produce 2,500 tons of the latter, containing 8 per cent. of nitrogen and 12 per cent. of phosphoric acid. The enterprise seems to have halted somewhat from the great difficulties to be overcome, but at last accounts still promised success.

The distance from markets and industrial centers, the wildness of the coast, the inclemencies of the weather, and the length of the arctic winter night, have all combined to make the successful manufacture of

the Norwegian products a very difficult matter. The bulk of the products have, I understand, been sold in Germany by Mr. Meinert, who has from the first had control of the trade in that country. Mr. Meinert has managed the business in such a straightforward and rational manner as to secure not only a large personal profit but also the confidence of the agricultural public. This he has done by personally aiding and encouraging the manufacture of an article of high grade and uniform quality, by selling it on the basis of guaranteed analysis, and thus recommending to the good sense of the most enlightened farmers.

According to Déharain (*Wurz Dict. Ch.* I, 1236), a Frenchman, M. Rohart, has established a manufactory of fish guano at Lofoden. This is probably the one referred to by Herr Meinert as "an incomplete imitation" of the previous manufactories there, and in aid of which the French Government gave a subvention of 100,000 francs. That so large a gift should be made to aid this enterprise is proof of the importance ascribed to it by the French Government.

According to the "Revue Scientifique," August 25, 1875, M. Levy has lately started an establishment at the French island of St. Pierre, in the Gulf of St. Lawrence, for the purpose of utilizing the gurry and offal of the codfish, &c., taken on the banks of Newfoundland. All the heads, entrails, &c., are gathered in, and after the extraction of the oil the residue is made into gelatine and fertilizers.

How important such an industry may be made appears from the fact that the waste material of the fisheries of that region is estimated at 120,000,000 pounds per annum.

Manufacture of glue and removal of oil in preparation of Norwegian fish guano.

287. It is worthy of note, that in the European factories the liquid coming from the steamed or boiled fish, and containing considerable nitrogenous matter in solution, is utilized for the manufacture of a low quality of glue, while in this country the practice is to throw it away.

The Norwegian guanos have generally smaller percentages of fat than occur in the menhaden guanos in this country. But even this small amount is objected to by many, on the ground that it retards the fertilizing action. According to Vohl, this objection has been removed by Radde, of Hamburg, by the manufacture of so-called fatless, evaporated, polar fish guano, in which a minimum of 8 per cent. of non-volatile nitrogen and of 12 per cent. of phosphoric acid is guaranteed, and actual analysis of a sample gave a considerable excess above this minimum. This article is in the form of a fine dry powder, of a yellowish color, with a comparatively feeble odor. It absorbs water rapidly, and when moist putrefies readily at 52°, with copious formation of ammonia. It yields on ignition 37 to 38 per cent. of ash.

Success of fish guano as a fertilizer in Europe.

288. A few words upon the use of fish guano in Europe may be in place here.

In 1855 Professor Stoeckhardt, of Tharand, wrote* of fish-refuse as a manure:

"Fish forms the basis of all natural guanos, since it forms the sole food of the sea-birds (and seals, &c.), from whose excrement guano is formed. * * * What is accomplished naturally here by the digestive processes of the bird, pulverization, fine division and concentration, must be done artificially by the ingenuity of the chemist. If the chemical and mechanical operations necessary for working over the crude material rapidly, on a large scale, into a product of good quality and at low price, can be devised, then it is for the interest of agriculture to be put as quickly as possible in possession of this product, whose office it may be to break the monopoly held by guano."

After describing at length the manufacture, composition, and fertilizing effects of materials prepared from fish, he warmly recommends them to the farmers of Germany as the "guano of the future."

At this time the fish guano was just coming into the European market; but little was known from experience or experiment as to its actual value for farming. In 1869, after it had stood the tests of repeated chemical analyses, gone through the trial of manifold field experiments, and run the gauntlet of practical farmers' experience, with ever-increasing popularity and favor, Stoeckhardt wrote again:

"Fish guano has entirely fulfilled the prophecy which I made for it fourteen years ago, at its first entrance into the commercial world, * * * and it is to be desired in the interest of agriculture that its manufacture may assume ever-increasing dimensions." * * *

The manufacture of fish fertilizers in the United States.

289. We may now return to the manufacture of fish fertilizers in the United States.

At present nearly all the material in our market is made from the menhaden, which after the extraction of the oil leaves a residue which is prepared in various forms for fertilizers.

The attempt of Mr. Lewis in East Haven, Conn., in 1848, to make a concentrated fertilizer from menhaden has been referred to. The first practical success in this direction was attained by Mr. W. D. Hall in 1853. "He discovered how the oil might be extracted from the fresh fish in a few hours' treatment, leaving the 'pomace' or 'scrap' in such a condition of half-dryness that it could be stored or barreled and transported at once, or could be further dried by exposure to the sun and converted by grinding into 'fish guano.'" The history of the manufacture of oil from menhaden since that time is given very fully in Mr. Goode's report on the menhaden.

* *Der Chemische Ackersmann*, 1855, *I*. 236.

Fish refuse and kinds of fertilizers made therefrom.

290. It is of interest for us to consider here the "scrap" or pomace left from the manufacture of the oil, and its uses.

The fish-refuse enters our markets in several different conditions. The following have come under my observation:

1. *"Crude stock," "green scrap," "chum," or crude pomace.*
2. *"Half dry scrap" or half dry pomace.*
3. *"Dry scrap" or dried fish.*
4. *"Dry ground fish-scrap," dry ground fish or "fish guano."*
5. *Fish guano from which the most of the fat has been extracted by special processes.*
6. *Acidulated fish.*
7. *"Fish and potash salts."*
8. *Fish mixed with superphosphates in the form of "ammoniated" superphosphates, sometimes called guanos.*

No. 1 is the raw material as it comes from the press.

No. 2 is the form it assumes after partial drying. More or less fermentation is apt to take place during the drying. This is often accompanied by considerable loss of nitrogen in the form of ammonia. Large quantities of this "half dry scrap," "half dry pomace," or "fish pomace," as it is variously called, are used by farmers along the coast where menhaden are taken.

No. 3 is the coarse scrap dried by the sun's heat or artificially. This also is used in large quantities by farmers near the coast.

No. 4 is prepared by grinding the dried scrap. It makes a reasonably fine, dry, quick acting, and excellent fertilizer.

The green scrap or crude guano generally contains 55 to 60 per cent. of water. The half-dry scrap contains 40 to 50 per cent. of water. The dry guano contains 10 to 20 per cent. of water.

The following measurements and estimates are said to be in use among menhaden manufacturers:

1 ton (2,000 pounds) is reckoned the weight of 3,000 fish.

2½ tons of fish yield 1 ton (40 per cent.) of green scrap, chum, or crude pomace.

3 tons of fish yield 1 ton (33 per cent.) of half dry scrap.

5 tons of fish yield 1 ton (20 per cent.) of dry scrap or guano.

One thousand menhaden, weighed by Mr. Dudley, president of the Quinnipiac Fertilizer Company, at Pine Island, June 12, 1877, weighed 685 pounds. Mr. Dudley has kindly furnished the following statements:

"We take them from the fishermen at so much per thousand, reckoning 22 cubic inches per fish. One thousand fish, measuring 22,000 cubic inches, weighs 667 pounds (3,000 to the ton).

"6,000 to 7,000 fish make 1 ton of 'green scrap' from the press. The last I weighed took 6,700 for a ton. Green scrap contains 55 to 65 per cent. of moisture.

"10,000 fish, on the average, yield 1 ton of half dry scrap, containing 40 to 50 per cent. of water.

"15,000 fish, on the average, make 1 ton of sun-dried scrap, containing 10 to 20 per cent. of moisture."

"In regard to prices for the past ten years, we have sold fish scrap or half dry fish, as it is called in Connecticut Valley, in car-load lots in bags, free on board cars at New London or New Haven, as follows:

"1869, $20 to $24 per ton; 1870, $23 to $25 per ton; 1871, $20 to $25 per ton; 1872, $16 to $19 per ton; 1873, $18 to $20 per ton; 1874, $19 to $23 per ton; 1875, $15 to $17.50 per ton; 1876, $17 to $20 per ton; 1877, $14 to $17 per ton; 1878, $17 to $18 per ton.

"Prices in bulk at factory are usually about $3 per ton lower than at New Haven, owing to cost of packages, labor, and freights. Dry ground fish guano was retailed ten years ago at $55 per ton, now at $40 to $42.50; wholesale, $5 per ton less."

Methods of manufacture and need of improvement.—Statements by Prof. C. A. Goessman.

291. The following statements from the Third Annual Report of the Massachusetts State Inspector of Fertilizers, Prof. Goessman, who has given a great deal of attention to the subject of fish manures, are of special value in this connection. Professor Goessman gives an analysis of a sample of dried fish scrap obtained at the chemical works under the charge of Hon. S. L. Goodale, at Booth Bay, Me., where large quantities of fresh scraps were delivered direct from the press of an adjoining fish-rendering establishment. It was deemed a particularly fair sample of a well-rendered and carefully-dried menhaden fish. It contained 10 per cent. of water, 70.75 per cent. organic matter, 18.25 per cent. ash, 8.46 per cent. phosphoric acid, and 8.14 per cent. nitrogen.

"About one third of the entire phosphoric acid proved to be soluble in citrate of ammonia. Ether abstracted at ordinary temperature 18 per cent. more of a thick, highly-colored, oily mass.

"The following rules of rendering the fish were stated as being customary in the establishment above mentioned: the fish were boiled for about one-half to three-quarters of an hour, by means of steam of from 70 to 80 pounds' pressure, in large wooden tanks with false bottoms; and subsequently, after the soup had been withdrawn, subjected to a pressure of about 115 to 120 pounds per square inch. The fish mass, in consequence of its gelatinous condition, retains usually still from 50 to 55 per cent. of moisture. In a large fish-rendering estabishment near New York City, I noticed that the boiling of the fish was continued only 25 minutes, with steam of 50 pounds' pressure, and the rendered fish mass subsequently treated with 160 pounds' pressure per square inch.

"The soup, which contains besides the oil more or less of the glue-producing, soluble nitrogenous matter of the flesh and the bones, is at present discharged after, by means of settling-tanks, the oil has been care-

fully removed. This practice causes a considerable waste of nitrogen. The yield of oil differs, often widely, even during the same season, being, it was stated, usually highest during autumn. The rendering begins usually in May or June, and closes late in the fall. The quality of the fish refuse in general, independent of its moisture and mechanical condition, depends, quite naturally, to a large extent, on the following circumstances:

"First. On the kind used and whether entire or in part.

"Second. On the peculiar mode of rendering.

"Third. On the time when the fish are caught.

"Fourth. The course pursued in keeping and preparing the refuse for the general market.

"Each of these circumstances exerts an influence of its own on the composition of the fish guano.

"Judging from general appearances, but little attention is paid thus far to the first three conditions; the influence of the last one is, more or less, fully understood, yet not satisfactorily controlled. A main difficulty, no doubt, arises from the irregular arrival of large quantities of fish at one time during the season; and the means, which are at present usually employed to meet this difficulty, are, quite frequently, inadequate to the demand. Many manufacturers of fish-oil consider it, therefore, apparently a safer proceeding to dispose at once of their crude stock at low rates than to run the risk any longer. Without questioning the soundness of their course of action, in case of limited pecuniary means, there seems to be no valid reason why improvements should cease here as long as it is daily demonstrated that it pays well to collect animal refuse matters from all over the country and to work them into valuable concentrated fertilizers.

"Nobody familiar with the nature of a good fish guano considers it less efficient for agricultural purposes than any other animal refuse matter of a corresponding percentage of phosphoric acid and nitrogen. In fact, all true guanos, the Peruvian not excepted, owe their most valuable constituents, in a controlling degree, directly or indirectly to the fish.

"Our fish guano consists of the entire body of the menhaden fish, which has been deprived purposely of its main portion of fat, and, incidentally, more or less completely of its soluble nitrogenous matter. The more the flesh predominates, the more the fat has been abstracted without the application of an excessive heat, as far as time and degree are concerned, the higher will be the commercial value of the residue of the press in case of an equal percentage of moisture. The flesh of the fish, like that of our domesticated animals, contains on an average 15 per cent. of nitrogen. The same close approximate relation exists between the bones and the textures of these otherwise widely differing classes of animals; for the fish-bones and the scales consist, mainly, of a varying quantity of cartilaginous (nitrogenous) matter and of (tricalcic phosphate) bone phosphate.

"To produce a fish guano which contains in a given quantity the largest possible amount of nitrogen, must be the principal aim of the manufacturer. It brings the highest pecuniary compensation; for one percentage of nitrogen is commercially equal to 4 per cent. of phosphoric acid.

"During the past, it is true, there has been little inducement for considerations of this kind on the part of the manufacturer, because practically there has been scarcely any serious discrimination on the part of the consumers regarding the exact relative chemical composition of the various fish guanos offered for sale.

"The future prospect of this branch of home industry depends, in an unusual degree, on the exertions which hereafter shall be made, on the part of the manufacturers, to meet the present more exacting conditions of the trade in fertilizers.

"To derive any full benefit from the capital invested renders it advisable, for all parties pecuniarily interested in the fish guano manufacture, to favor a closer scientific investigation into the changes which the menhaden fish undergoes during the customary mode of rendering.

"Loss of nitrogenous matter, in consequence of misapplication of heat, seems to be not always compensated for by an increase of the yield in oil.

"The latter, when left in the fish mass in an undue proportion, reduces, to say the least, the commercial value of the guano by adding a worthless matter, which may affect seriously the analytical results, as far as its percentage of nitrogen is concerned. To heat the fish to a higher temperature, or for a longer period of time than is required to secure the largest possible amount of oil, reduces, invariably, the commercial value of the fish mass for agricultural purposes. A few subsequent analytical statements, regarding the composition of fish, and the degree of the changes which they may suffer by steaming and rendering, may serve as a practical illustration of my previous remarks.

"A well-dried and finely-ground fish guano is one of our best substitutes for Peruvian guano, and ranks equally high with the best quality of animal dust from our butcher refuse establishments. It deserves the liberal patronage of farmers wherever a rich nitrogenous phosphate is called for.

"I have shown in a previous report, that, as a general rule, the high grades of superphosphates are cheaper than our low grades; the same rule applies to nitrogenous materials.

"The recent changes in our fertilizer trade tend to stimulate improvements in the modes of their manufacture, by rendering true merits prominent, which, as a natural consequence, secures a reliable patronage only to the best quality. We are not yet suffering from an overstocking of our fertilizer markets on account of overproduction of home-made fertilizers obtained from suitable home resources.

"Millions of dollars are annually sent abroad still, for the importa-

tion of materials, which, in their crude form, are by no means better than what we have in abundance at home.

"The manufacture of fertilizers has become in the same degree an art, as agriculture itself has justly assumed the claim of being a science.

"The production of fish guano, although respectable already, as far as quantity is concerned, is thus far but incidental to the menhaden fish-rendering industry.

"It remains still an open question whether our resources for the manufacture of fish guano do not extend beyond that branch of industry."

Statements of Mr. Maddocks.—Manufacture in Maine.

292. From the fifth report of the secretary of the association of the menhaden oil and guano manufacturers of Maine, Mr. L. Maddocks, which is devoted to "The Menhaden Fishery of Maine," the following quotations are taken. The manufacturing processes are those prevalent on the Maine coast, particularly in the region of Booth Bay:

"The fish [as brought in by the fishing vessels] are discharged into a car running upon a rail-track to the second story of the factory, and thence poured into tanks below, holding sixty to seventy-five barrels. These are filled one-third with water, steam turned on, and the fish cooked an hour, or until the albumen is coagulated, and the oil-cells broken. The cooked mass, after draining, passes into presses worked by hydraulic power, and is subjected to the pressure of a hundred tons per square inch, the oil and water flowing out and being collected in vats. The oil is then drawn off, clarified by settling, barreled, and is ready for market. The residue, called chum or scrap, is usually stored in the lower story of the factory until taken away by the purchasers, chiefly the manufacturers of ammoniated superphosphate of lime.

"The following figures will give more definiteness to the statement:

"One hundred and ninety-five pounds of fish make a 'barrel.'

"One barrel yields about two and a half gallons of oil, or eighteen and three-quarter pounds."

"One barrel yields about eighty pounds of fresh chum or scrap.

"These are average results of the manufacture as now conducted in this State. The amount of oil realized varies from one gallon per barrel of fish, early in the season, to four or five gallons in September."

"The scrap contains, on the average as it comes from the press, 55 to 60 per cent. of its weight in water, and sometimes more. This is of course worthless for fertilizing purposes. It also contains from 12 to 20 per per cent. of fat or oil, which is equally worthless for manure.

"As now generally managed, the scrap remains in large heaps until shipped, in autumn or winter, to the points of manufacture into superphosphate. In this time a portion of the oil and water leaks away, so as to leave about 10 or 15 per cent. of the former, and 48 to 53 per cent. of the latter. The elimination of the water is an advantage, but the

specified per cent. of oil is lost, and a portion of nitrogen is also lost, resulting from the partial decomposition of the mass, the formation and escape of ammonia. It were better, if practicable, to drive off the water at once upon withdrawal from the press, so as to prevent the loss in question."

Goodale's new process.

293. I have spoken of fish guanos from which the most of the fat has been extracted by special processes (Class No. 5, of page 000). One of these is Mr. Goodale's, of which Mr. Maddocks speaks as follows:

"What has hitherto prevented the driving off of the water immediately by artificial heat has been the presence of so much oil, together with the gelatinous or gluey matter which is developed during the cooking, chiefly from the skins and bones. These render the process of drying the scrap a very difficult and tedious one, so much so that comparatively little has been put into the market in that desirable form. The recent discovery of an easy and simple process for removing the larger part of the oil, and also at the same time the gelatinous hinderance to drying, gives promise of a speedy change in this respect. While pursuing investigations relative to utilizing the menhaden as a source of concentrated food, before referred to, Mr. S. L. Goodale, formerly secretary of the board of agriculture, discovered that it was chiefly by the agency of the gelatine that the remaining oil was held in the scrap. He found by thoroughly washing new scrap with sufficient hot water, and agitation, that it lost its jellyish consistence and slimy feel, and that the oil globules were liberated from their lock-up in the tissues, so that the greater part could be easily recovered by draining and repressing, and also that after such washing it could be pressed much drier than before.

"We can now readily understand why it is that oil, together with a putrid, watery liquid, leaks away from new scrap not many days after it is removed from the press. It is simply because dissolved gelatine, being more readily putrescible than other animal substances, quickly decomposes, and changes to a thin, offensive liquid, which partly drains off. This decomposition, or the change of consistence attending it, so 'lets the bars down,' that more or less oil escapes, while subjected to no pressure whatever, except its own weight.

"Thus by a very easy process, the oil product may be largely increased, the scrap left free from the gluey hinderance to drying, and with less water to be dried out.

"It may appear strange that so simple a method should not have been discovered sooner, but such is the fact. Work had been done on both sides of it. Re-pressing had been tried, using extra strong curbs, with very powerful pressure, but it failed to give satisfactory results. Re-cooking had been resorted to, which resulted in injury to the oil and in the development of an additional amount of the gelatinous matter. It is now seen that a simple thorough washing in hot water accomplishes the desired end, with neither of these objectionable results.

"Scrap made by this process last August (1877), and dried in the open air, was lately analyzed at the agricultural experiment station of Connecticut, and the statement of the director, Prof. S. W. Johnson, of New Haven, shows the proportion of moisture to be reduced to 11.45 per cent., or about one-fifth that contained in the scrap fresh from the press; and the proportion of *oil* to 4.65 per cent., thus proving that the content of oil in the *washed scrap as it came from the press* (before drying it) had been reduced to less than 2½ per cent. [The percentage of nitrogen was 10.24 per cent., the phosphoric acid 7.50 per cent. These figures refer to the material as dried in the open air.]

"According to these figures, the proportion of oil hitherto lost is, by the new process, reduced from an average of, say 15 per cent. of the weight of the scrap as it commonly issues from the press, to about 2 per cent. The balance, say 12 or 13 per cent., is saved. Let it be assumed, however, that only 10 per cent. can be realized in practice, and that the annual out-turn of scrap from the factories of the Maine association be only 40,000,000 pounds. This would give an annual saving of 4,000,000 pounds of oil, or 533,000 gallons, worth, at current prices at market for 1877, forty cents per gallon, $213,200.

"With reference to drying by artificial means, which is obviously important, no doubt is felt that the apparatus now in operation will effect the work as thoroughly as may be desired, and cheaply and quickly also, provided only the oil and gelatine in the scrap be reduced as above described.

"Two companies belonging to the association have succeeded in drying the scrap in considerable quantities, notwithstanding the obstacles referred to. The scrap is passed through a slightly inclined heated iron cylinder thirty feet long and four feet in diameter, and on the passage is agitated by paddles attached to a revolving shaft, and comes out at the lower end dried to about 25 per cent. of moisture. The process will be greatly promoted in dispatch and efficiency by the application of the new oil-saving method, and the whole manufacture will then be under full control. The scrap can at once, upon withdrawal from the press, be subjected to the drying process by furnace heat, irrespective of the state of the weather, and thus the loss of ammonia by decomposition be forestalled. If the contained moisture is reduced to a per cent. no lower even than 20 or 25, the scrap can be kept on the spot at convenience, and without offense to the senses, or transported as required."

Adamson's process.

294. The other process for extracting fat from fish is that of Adamson. It depends upon the use of hot petroleum, naphtha, or benzine, to dissolve the oil. Whole fish, menhaden, or others, as well as scrap, are said to be arranged in layers, in an inclined iron cylinder, the naphtha or benzine directed upon and passed through them. In the passage the oil is extracted from the fish, which are left in an excellent form for dry-

ing and grinding. The process is said to be easy, simple, and effectual. The main drawback is the necessity for new apparatus and the rejection of a good share of the appliances now used.

Two samples of fish guano prepared in this way and analyzed at the Connecticut experiment station gave, respectively:

	Per cent.	Per cent.
Moisture	4.91	3.67
Oil	2.07	....
Nitrogen	10.78	10.74

Immense waste of fish at present.—Possibilities of future manufacture.

295. The accounts of these new processes at my disposal are meager. They seem, however, to promise well, and, if successful, must revolutionize the manufacture of fish guano. The great desideratum has been a means of removing the oil as entirely as possible, saving the nitrogenous matters and yielding a fine, dry product. This seems to have been found. I understand that the Adamson process is to be used in the manufacture of a fertilizer from the fish that are taken along the coast, but thrown into the sea again on account of their low value for oil or food. The benefit to our agriculture from such an economizing of fish hitherto wasted would be immense. Concerning the number of fish thus lost Mr. Goode writes: "I estimate that the amount of fish annually thrown away from the hundred and fifty-odd weirs on our coast cannot fall much short of ten millions of pounds annually, and probably far exceeds that."

"Acidulated fish" and "fish and potash salts."

296. The "acidulated fish" (class No. 6 on page 219) is prepared by treating the fish scrap with sulphuric acid to render the phosphoric acid more soluble. Unfortunately the constitution of the tissues of the fish is such as to resist the action of the acid, and the desired result is only partly attained. A sample examined under the writer's direction gave 7.09 per cent. of phosphoric acid, of which only 1.76 per cent. was soluble in water.

It will be remembered that Pettitt's process for the manufacture of fish waste into a fertilizer was based upon treatment of the fish with acid, and did not prove a success.

Various efforts in this same direction are reported in this country and in Europe, but none, as I can learn, have been found profitable. The imperviousness of the tissues to the action of the acid has thus far been an insurmountable obstacle to success, and will probably remain so.

The "fish and potash salts" (class No. 7, above) is a mixture, as its name represents, of fish, half-dry scrap apparently, in the specimens I have seen, with German potash salts. The idea is a sound one, in that the salts used, doubtless of the lower grades, like Leopoldshall Kainit, and containing large percentages of chloride of sodium (common salt),

would act as a preservative, and further, the potash supplies a lack in the fish and makes of it a "complete" fertilizer.

The amounts of the "acidulated" fish and "fish and potash salts" in the market are so small as to give them very little importance.

Manufacture of "ammoniated superphosphates."

297. The most important use of fish waste is in the manufacture of nitrogenous, "ammoniated," superphospates. These fertilizers, which constitute by far the largest class in the market, owe their value mainly to the two ingredients, nitrogen and phosphoric acid. For phosphoric acid various fossil and mineral phosphates, particularly those from South Carolina and the Island of Navassa, are employed. Of late, mines of apatite have been opened in Canada, and promise to be a rich and important source of phosphates for this purpose. The waste boneblack from sugar refineries is also used in very large quantities for the same purpose. Bone meal is likewise employed, but to a limited extent. The phosphoric acid in all of these is in insoluble or very slowly soluble forms. To render it more available, the phosphates are treated with sulphuric acid, and thus superphosphates are produced.

Various materials are used to supply nitrogen (ammonia) to superphosphates. Dried blood and meat-scrap from slaughter-houses are, next to fish, the most important materials in common use for this purpose. Formerly a good deal Peruvian guano was employed. In Europe considerable sulphate of ammonia is used, but manufacturers there are learning that they can get nitrogen cheaper in American fish and slaughter-house products, and thousands of tons of our best nitrogenous materials are annually taken from us and sent across the Atlantic to enrich English, French, and German soils.

According to the report of Mr. Maddocks, already referred to, "nine-tenths of the fish scrap turned out at the works of the Maine association are bought by the manufacturers of superphosphate to ammoniate their products, of which 400,000 tons are produced yearly in the United States. They combine it, when dried and pulverized, with South Carolina phosphatic rock, ground bones, with imported guano deficient in ammonia, &c. It is understood that not over one ton of the fish guano is used in connection with three or four tons of the mineral ingredients."

The largest manufacturers of superphosphates in this country are the Pacific Guano Company, whose works are at Wood's Holl, Mass., and near Charleston, S. C. This company use fish and the Charleston phosphate for the manufacture of their superphosphate, the "Soluble Pacific Guano." The Quinnipiac Fertilizer Company, of New Haven, Conn., whose works are on Pine Island, near New London, Conn., and the Cumberland Bone Company, of Boothbay, Maine, are, with the Pacific Guano Company, the best representatives of this most useful industry. The detailed descriptions of their factories and methods of manufacture, prepared by Mr. Goode, are at once too extensive to be

conveniently inserted here, and of too much interest to be condensed, and are therefore given in the Appendix O.

50. CHEMICAL COMPOSITION OF MENHADEN AND OF FISH MANURES.

Analysis of whole menhaden and of flesh and bones of whale.

298. The only analysis of whole menhaden I have noticed is given by Prof. G. H. Cook.* The specimens were taken in the Raritan River the latter part of October.

"Five of the fish weighed four and one-fourth pounds—their average weight being three quarters of a pound. The oil was first separated by adding water to the fish and boiling until the flesh was reduced to a pulp. The oil was then skimmed off and purified from water and other substances by ether. It then weighed 2.66 ounces, which is equivalent to 3.914 per cent. of the original weight of the fish. The substance of the fish remaining was then strained out and carefully dried in an air bath, at a temperature of 290° F., when the dry mass was found to weigh 11.8 ounces. On account of the solvent power of the sulphuric acid, which was added to the fish, it was thought proper to separate all the mineral matters from the fluid in which the fish had been boiled, add them to the dried fish, excluding of course the sulphuric acid. These weighed 1.1 ounces, and added to the weight of dried fish given above, 11.8 ounces, made for the whole weight of the dried matter 12.9 ounces, which is equivalent to 18.93 per cent. of the original weight of the fish. There was still left in the fluid some animal matter, which could not be satisfactorily separated, and was left out. The water in the fish was 77.15 per cent. as ascertained by deducting the percentage of oil and dried matter from 100. The nitrogen in the dried fish was ascertained by ultimate analysis to be 7.76 per cent., which is equivalent to 9.28 per cent. of ammonia. The mineral substances contained in the fish were freed from the organic matter by pressing, and then separated from each other by the ordinary process of analysis."

Analysis of the fresh fish.

Water	77.150
Oil	3.914
Dried fish	18.936

Analysis of the dried fish.

Lime	8.67
Phosphoric acid	7.78
Silicic acid	1.33
Potash	1.54
Soda	1.02
Magnesia	0.67
Chlorine	0.69
Organic matter and loss	78.30
	100.00

* Geology of New Jersey, 1868, p. 497.

The following analysis by Stöckhardt* of the flesh and bones of the whale may not be without interest in this connection :

I.—*Flesh of the whale.*

	Raw, per cent.	Perfectly dry (incuding fat), per cent.	Without fat and entirely dry, per cent.
Water	41.50	....	....
Fat	22.81	49.70	....
Flesh	32.10	57.44	96.80
Mineral constituents (ash)	1.04	1.86	3.20
Nitrogen	4.86	8.68	14.60

II.—*Steamed bones of the whale.*

Water	3.84 per cent.	
Cartilaginous mass (glue)	34.60 "	=(3.5 per cent. nitrogen.)
Fat	1.34 "	
Bone phosphate of lime	51.66 "	=(23.66 per cent. phosphoric acid.)
Carbonate of lime	8.56 "	

Analysis of fish fertilizers.

299. The following tables illustrate the composition of some of our more common fish fertilizers. Those in Table A are from analyses reported by the writer.† Those in Table B are reported by Prof. S. W. Johnson: ‡

TABLE A.

Kind of fertilizer.	Station number.	Moisture.	Organic matter.	Ash.	Phosphoric acid.	Nitrogen.	Ammonia equivalent to nitrogen.	Oil.
Dry ground fish:		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Ground fish, G. W. Miles	10	18.74	61.82	19.44	7.65	8.06	9.78	6.71
Fish guano, G. W. Miles	28	21.96	50.99	27.05	8.66	6.07	7.36	....
Charles Island guano, G. W. Miles	80	8.63	71.79	19.41	7.74	8.84	10.73	....
Allyn's fertilizer	24	....	....	16.37	6.17	8.80	10.68	6.35
Allyn's fertilizer	185	6.34	71.31	22.35	7.90	7.88	9.56	7.33
Dry ground fish, Quinnipiac Fertilizer Company	100	14.64	....	22.23	6.67	7.50	9.11	7.68
Dry ground fish, Quinnipiac Fertilizer Company	140	10.85	68.40	20.75	7.21	7.38	8.97	....
Dry ground fish, Quinnipiac Fertilizer Company	172	13.45	63.97	22.58	7.55	7.96	9.66	6.63
Dry ground fish, Quinnipiac Fertilizer Company	203	8.22	....	20.41	8.11	8.25	10.00	8.94
Acidulated fish, Quinnipiac Fertilizer Company	222	36.53	39.89	23.58	*7.09	4.11	4.99	....
Dried fish scrap:								
"Dry fish," Green Brothers	179	11.04	64.01	24.95	10.51	8.60	10.44	3.93
"Dried fish"	182	9.37	....	19.92	7,10	8.13	9.86	....
"Dry fish"	189	11.00	....	20.17	7.12	7.46	9.05	8.29
"Fish scrap"	190	7.74	....	....	....	7.10	8.61	....
"Dry fish"	196	7.59	....	....	....	7.79	9.46	....
"Dry fish"	199	....	....	....	....	7.65	9.28	....
Half-dry fish scrap:								
Fish scrap, "half dry"	103	40.95	43.06	15.99	6.23	5.33	6.47	....
Fish scrap, "half dry"	131	25.10	56.17	18.73	7.49	5.49	6.66	11.99
Crude fish pomace:								
"Fish scrap"	197	56.83	....	....	....	3.63	4.41	....

* Per cent. soluble in water, 1.76; per cent. soluble in ammonium citrate, 2.47.

* Chemische Ackersmann XVI, 1870, 52.

† Report of Connecticut Agricultural Experiment Station, 1876, p. 63.

‡ Report of Connecticut Agricultural Experiment Station, 1877, p. 41.

TABLE B.

Kind of fertilizer.	Station number.	Moisture.	Nitrogen.	Nitrogen in water-free fish.	Oil.
		Per ct.	Per ct.	Per ct.	Per ct.
Dry ground fish-scrap	2	10.75	8.52	9.54	....
Dry ground fish-scrap	12	....	8.21	....	....
Dry ground fish-scrap, old, 1876	15	16.59	7.35	8.81	....
Dry ground fish-scrap, new, 1877	16	23.95	7.30	9.59	....
Dry ground fish-scrap	17	....	9.26	....	....
Dry ground fish-scrap	18	....	8.77	....	....
Dry ground fish-scrap	22	19.57	7.98	9.92	....
Dry ground fish-scrap	43	9.03	8.04	8.83	....
Dry ground fish-scrap	45	11.38	8.51	9.60	....
Dry ground fish-scrap	46	10.74	8.43	9.44	....
Dry ground fish-scrap	50	9.76	7.77	8.61	8.94
Dry ground fish-scrap	52	11.19	8.78	9.88	7.30
Average		13.66	8.24	9.36	8.12
Fish by Adamson's process	36	4.91	10.78	11.32	2.07
Fish by Adamson's process	39	3.67	10.74	11.15	....
Fish by Goodale's process	41	11.45	10.24	11.56	4.64

Waste from faulty manufacture and use of fish fertilizers.

300. An enormous loss results to our agriculture from the waste of fish that might be saved, from faulty manufacture of fish into fertilizers, from wrong use of the fertilizers when made, and from the exportation of the best products to Europe, where their value is better understood. This loss will be prevented in proportion as the nature and uses of fish manures are learned.

51. THE USE OF FISH FERTILIZERS IN AGRICULTURE.

Chemistry of plant nutrition.

301. Not only farmers and merchants, but many manufacturers as well, have a very poor understanding of what constitutes the value of fish as fertilizers, and how they may be most economically utilized. It will be well, therefore, to consider briefly some of the principles that decide the value and usefulness of fertilizers in general, and of fish products in particular.

Fish manures, like other commercial fertilizers, are valuable because they supply plant-food which crops need and soils fail to furnish. Their main value depends upon their content of nitrogen and phosphoric acid. These are the most valuable and costly ingredients of commercial fertilizers.

Plants, like animals, require food for life and growth. A part of the food of plants is supplied from the atmosphere, the remainder is derived from the soil. No ordinary cultivated plant can thrive without a sufficient supply of each of a number of substances needed for its food. With an abundance of all of these in forms in which the plant can use them, and with other circumstances favorable, the plant will flourish and the yield be large. But if the available supply of any one of them

be too small, a light yield is inevitable. For instance, *potash* is an *essential ingredient* of the food of plants. If all the other conditions for a profitable crop of corn or potatoes, or other plants, are fulfilled in the soil, except that potash is deficient, the crop will inevitably fail. But if the potash be supplied the yield will be abundant. The chief use of fertilizers is to supply the plant-food which the soil lacks.

Vegetable and animal substances, and manures and soils as well, contain, besides *water*, two kinds of materials, the so-called *organic matter* and the *mineral matter* or *ash*.

The *organic matter* consists chiefly of the four chemical elements, *carbon*, *oxygen*, *hydrogen*, and *nitrogen*. We do not need to trouble ourselves about the first three of these in fertilizers, because they are supplied to the plant in abundance by the atmosphere and the soil through the leaves and through the roots.

But the nitrogen is an important ingredient of fertilizers. It is, in its pure state, a gas, and makes up about four-fifths of the air. Combined with hydrogen it forms ammonia; combined with oxygen it is known as nitric acid. In these and other combinations it occurs in minute quantities in the atmosphere, and in considerable quantities in soils and manures. Plants are unable to make use of the pure nitrogen of the air, though some, if not all, absorb a very little combined nitrogen from the atmosphere. By far the largest part of the nitrogen of plants is absorbed from the soil through the roots. From the facts that nitrogen is available to plants only in certain combinations, that it is slow to form and easily leaves these compounds, that it readily escapes from manures and soils into the air, and is leached away by water, it is one of the most commonly deficient and hence the most costly ingredients of the food of plants.

The mineral matter or ash of plants is derived entirely from the soil. It consists of several ingredients, known as potash, soda, lime, magnesia, iron, silica, sulphuric acid, phosphoric acid, and chlorine.

Essential ingredients of plant-food.

302. The results of a vast amount of this sort of experimenting prove that no agricultural plant can attain full growth without a sufficient supply, through its roots, from the soil, of *potash*, *lime*, *magnesia*, *iron*, *phosphoric acid*, *sulphuric acid*, and some compound of *nitrogen*. Besides these, chlorine, and perhaps silica, are sometimes, if not always, indispensable, though in very small proportions, to complete development. If any one of these *essential ingredients* be lacking the plant will suffer in growth and development.

Exhaustion of soil by various crops.

303. Crops take from the soil, then, the materials needful for their growth; and these are rightly called "plant-food." Some soils yield large crops many years in succession without manuring. They do this

because they contain large stores of the ingredients of plant-food, as potash, lime, nitrogen, &c., and because these are furnished in available forms, so that the plant can readily use them. As a rule, after cropping for some time, the point is reached where the natural resupply of plant-food is insufficient to produce large crops. In other words, in the so-called "poor," "worn-out," or "exhausted" soils, the natural strength is insufficient for profitable production.

In order to know what fertilizers to use on such soils we must know what ingredients of plant-food are deficient, and what manures will best supply them. An idea of the essential ingredients of plant-food removed from the soil in cropping may be obtained from the table below, which is calculated from the extensive tables of analyses of plants by Wolff.

Materials removed from the soil by various crops.

Crops.	Sulphuric acid.	Phosphoric acid.	Lime.	Magnesia.	Potash.	Nitrogen.
RYE.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Grain, 25 bushels = 1,400 pounds	0.3	11.8	0.7	2.9	7.8	24.6
Straw, 3,500 pounds	3.8	7.3	12.2	3.9	27.3	14.0
Total	4.1	19.1	12.9	6.8	35.1	38.6
OATS.						
Grain, 30 bushels = 960 pounds	0.4	6.0	1.0	1.8	4.2	18.4
Straw, 2,000 pounds	2.6	3.8	7.2	3.2	17.8	11.2
Total	3.0	9.8	8.2	5.0	22.0	29.6
WHEAT.						
Grain, 20 bushels = 1,200 pounds	0.1	9.5	0.7	2.4	6.4	25.0
Straw, 3,000 pounds	3.3	6.6	8.1	3.3	18.9	14.4
Total	3.4	16.1	8.8	5.7	25.3	39.4
CORN.						
Grain, 50 bushels = 2,800 pounds	0.6	16.5	0.8	5.6	10.4	44.8
Stalks, 6,500 pounds	7.8	34.5	26.0	16.9	62.4	31.2
Total	8.4	51.0	26.8	22.5	72.8	76.0
HAY.						
Mixed grasses, 1½ tons = 3,000 pounds	7.2	12.3	25.8	9.9	39.6	46.5
POTATOES.						
Tubers, 150 bushels = 9,000 pounds	5.4	1.44	1.8	3.6	51.3	30.6
TOBACCO.						
Leaves, 1,800 pounds (1,260 pounds dry)	14	7.5	73	17	71	49
Stalks, 1,100 pounds, dry	3	15	15	2	47	33
Total	17	22.5	88	19	118	82

Large quantities of silica, and small quantities of soda, chlorine, and iron, are also removed from the soil by every crop. Iron is necessary to the growth of all agricultural plants, but in very minute quantity. In many cases small amounts of chlorine seem to be requisite. Silica, if needed at all, which is quite doubtful, is required only in extremely

minute proportions. Soda does not appear to be an essential ingredient of plant food. In so far as these latter are *essential* ingredients of plant food, they are furnished in abundance by every ordinary soil.

Ingredients most commonly lacking in worn-out soils, and hence most important in fertilizers; nitrogen, phosphoric acid, and potash.

304. For our present purposes, then, we have to consider only the potash, lime, magnesia, sulphuric acid, and nitrogen. Of this list the magnesia is commonly, though not always, supplied in sufficient quantities in even "worn-out" soils. Sometimes its presence in fertilizers may be of considerable importance to crops. Sulphuric acid and lime are more often deficient, and hence one reason of the good effect so often observed from the application of lime and plaster.

The remaining substances, the nitrogen, phosphoric acid, and potash, are the most important ingredients of our common commercial fertilizers, because of both their scarcity in the soil and their high cost. It is in supplying these that fish guano, phosphates, and bone manures are chiefly useful.

In brief, then, in order that crops may grow, they must have at their disposal an adequate supply, in available forms, of each one of a certain list of essential ingredients of their food. Soils differ in respect to their supplies of these food ingredients. The crop cannot rise above the level of the lowest ingredient in the food supply. The chief use of fertilizers is to fill up the gaps.

Principles to be observed in the manufacture and purchase of fertilizers.

305. The cardinal principle to be observed by the farmer in the purchase of fertilizers is, to—

Select those which furnish, in the best form and at the lowest cost, the ingredients of plant-food that his crops need and his soil fails to supply.

The principle that should guide the manufacturer should be, to—

Economize all available materials in his manufacture so as to furnish the valuable ingredients in the best forms in products of high-grade and uniform composition, and at the fairest practicable rates.

The most important ingredients of our fertilizers, because the most rare and costly, are nitrogen, phosphoric acid, and potash. The two first are the most important. These are supplied in large proportions in fish.

Composition, character, costs, and uses of fertilizers in general.

306. It will be to our purpose, then, to note briefly:

1. The composition of some of our more important commercial fertilizing materials, particularly those which, like fish manures, contain nitrogen and phosphoric acid; in other words, the analyses of these fertilizers.

2. The comparative costs and values of the active fertilizing ingredients in these articles; or, in other words, the commercial valuations.

3. The forms of combination in which the valuable ingredients occur, and their consequent agricultural values.

4. Some of the ways in which the fertilizers may be improved, and their values increased.

In the consideration of these topics, which must be brief, some data will be used which may be found in more detail in previous articles and reports by the writer.*

Explanations of chemical terms used in fertilizer analyses.

307. The following explanations of terms used in fertilizer analyses will be of use to those not familiar with such subjects:

MOISTURE.—All fertilizers contain more or less water, which, of course, has no commercial value, and serves to make them heavier and relatively poorer in valuable ingredients. In the analysis, that which is removed by heating to 212° Fahrenheit (or, in some cases, to a somewhat higher temperature) is designated as moisture. By subjecting the dried material to a higher temperature, the organic and volatile matters are driven off, and the ash remains. By treating this ash with strong acids, all that is of any value is dissolved.

SAND AND INSOLUBLE MATTERS.—The residue, which resists the action of both fire and strong acids, consists of silica and other mineral matters. These possess no fertilizing value, and are classified as sand, &c.

NITROGEN. AMMONIA.—In our ordinary fertilizers much or all of the nitrogen exists in unavailable forms. By more or less rapid alterations, by decay or otherwise, which take place in the soil, these are changed to other compounds, which the plant can readily use as food. Of these latter, nitric acid, which contains nitrogen combined with oxygen, is one; ammonia, which consists of nitrogen and hydrogen, and is represented by the chemical formula NH_3, is another. Fourteen parts by weight of nitrogen unite with 3 parts of hydrogen to form 17 parts of ammonia. Accordingly, 14 parts of nitrogen are said to be equivalent to 17 of ammonia, or what is the same thing, 100 parts of nitrogen are reckoned as equivalent to 121 parts of ammonia. In pure sulphate of ammonia all the nitrogen is in the form of ammonia. In Peruvian guano some of the nitrogen exists as ammonia also. In our other ordinary fertilizers there is little or no ammonia. The very common practice of reckoning nitrogen as ammonia in fertilizers which do not contain it in this form is incorrect, misleading, and therefore wrong, and ought to be abolished.

Ammonia combined with sulphuric acid forms sulphate of ammonia; nitric acid combined with soda forms nitrate of soda.

PHOSPHORIC ACID: SOLUBLE, REVERTED, AND INSOLUBLE.—By phosphoric acid is understood the compound of phosphorus and oxygen which is represented by the chemical formula P_2O_5, or PO_5. This, combined with lime, forms phosphate of lime. The phosphate of lime which

* See particularly report of Conn. Agl. Expt. Station in Report of Conn. Board of Agriculture for 1876.

occurs in bones, and in South Carolina and other fossil and mineral phosphates, contains 3 parts of lime to 1 of phosphoric acid. This is often called bone phosphate, and is insoluble in water. When the bone phosphate is treated with sulphuric acid, the latter takes part of the lime to itself, forming sulphate of lime, and leaves the phosphoric acid in the form of a *superphosphate*. This last is soluble in water, is more readily diffused through the soil, and when used as a fertilizer can be taken up by the plant at once, while the bone phosphate is slowly available as plant food. Phosphoric acid which has been rendered soluble often enters into other forms of combination, with lime, aluminia, &c., which, though insoluble in water, are soluble in citrate of ammonia. The terms "reverted," "reduced," and "precipitated" are applied to it when in this form. The reverted phosphoric acid ranks in solubility, in capability of diffusion through the soil, and consequently in value, between the soluble and insoluble. The soluble and reverted are sometimes classed together as available phosphoric acid.

In some analyses the percentage of phosphoric acid is not stated separately, that of "bone phosphate of lime" being given in its stead. Sometimes the expression "soluble bone phosphate of lime" is met with, which is certainly a misnomer. One hundred parts by weight of phosphoric acid unite with about 118 parts of lime to form 218 parts of bone phosphate; 100 parts or pounds of phosphoric acid are said, therefore, to be equivalent to 218 parts of bone phosphate. I lay especial stress on this point, because those not familiar with chemistry are apt to be deceived in comparing analyses in some of which the term phosphoric acid and in others the term bone phosphate is used. It would be more accurate and clear, and in every way better, to discard the term bone phosphate of lime in analyses of fertilizers, and speak only of phosphoric acid.

POTASH, OR POTASSA, is the compound of the metal potassium with oxygen, which is represented by the chemical formula K_2O or KO. This, combined with sulphuric acid, forms sulphate of potash. Potassium and chlorine together form chloride of potassium, or "muriate of potash," as it is called by dealers.

As the analyses and the valuations of the fertilizers to be discussed can be given most concisely and clearly together in tables, explanations of the latter subject may properly be given here.

Valuations of commercial fertilizers.

308. The *agricultural value of a fertilizer*, the gain which will result from its use in a given case, is subject to such varying conditions of soil, climate, culture, and crop, as to preclude the possibility of exact estimate. The *commercial value*, being dependent upon its composition and the state of the market, admits of more nearly correct calculation.

It is customary to make estimates of the commercial values by attributing to each of the important ingredients a certain value per pound;

that is to say, each pound of nitrogen, phosphoric acid, and potash is rated at a certain price, and the value of a ton of the fertilizer calculated on this basis, just as a grocer would make out a bill for a lot of tea, coffee, sugar, by charging a certain price per pound for each, and adding the products to make the amount of the bill. It will be remembered that each per cent. or pound in 100 pounds will be equal to 20 pounds in a ton of 2,000 pounds.

Here, for instance, is an analysis and valuation by Professor Goessmann:

Fish guano.

	Per cent.
Moisture at 100°–110° C	17.50
Organic matter	53.20
Ash constituents	29.30
Phosphoric acid in ash	7.72
Nitrogen in organic matter	6.46
Valuation per ton of 2,000 pounds:	
154.4 pounds of phosphoric acid, at 6 cents per pound	$9.26
129.2 pounds of nitrogen, at 25 cents per pound	32.30
	$41.56

The following statements are from the Connecticut experiment station report for 1876.

The statements and tables given in the other parts of this report will supply sufficient data for judging the values of nitrogen, phosphoric acid, and potash in different forms in which they are most commonly obtained in the markets. The commercial value of a fertilizer of which the analysis is given may be calculated by the following rule:

I. Multiply the per cent. of each valuable ingredient by 20 to get the number of pounds in a ton of 2,000 pounds. Multiply the number (thus found) of pounds of each ingredient by its assumed value per pound. The sum of these products will be the estimated commercial value of a ton of the fertilizer. Or,

II. Multiply the number of "units" (per cent.) of each ingredient by the assumed value per unit, and add the products. The sum will be the estimated value per ton.

What will be fair valuations will depend upon the material by which they are furnished, their market value at the time, the amounts purchased, time of payment, distance from market, &c. For the common superphosphates, bought in ton-lots for cash in our larger cities, the following figures will not be far out of the way:

	Per pound.	Per unit.
Nitrogen	21 cents.	$4 20
Phosphoric acid, soluble	12½ cents.	2 50
Phosphoric acid, reverted	9 cents.	1 80
Phosphoric acid, ins., from bones, meat, or fish	6 cents.	1 20
Phosphoric acid, ins., from bone-black	5 cents.	1 00
Phosphoric acid, ins., from fossil and mineral phosphates	3½ cents.	65

It must be remembered, however, that the values thus calculated are not agricultural values.

The following rates of valuation were adopted by Professor Goessmann in 1874-'75 and 1875-'76:

	1874-'75. Per pound.	1875-'76. Per pound.
Soluble phosphoric acid	16.25 cents.	12.5 cents.
Reduced	13 cents.	10 cents.
Insoluble phosphoric acid in mineral phosphates	5 cents.	4 cents.
Insoluble phosphoric acid in bones, fish, and animal dust	6 cents.	6 cents.
Nitrogen	30 cents.	25 cents.
Potassium oxide in muriate	8 cents.	6 cents.
Potassium oxide in sulphate	8 cents.	8 cents.

Professor Johnson, in the report of the Connecticut station for 1877, says as follows:

"The following are the trade-values or cost in market, per pound, of the ordinarily occurring forms of nitrogen, phosphoric acid, and potash, as recently found in the New York and New England markets:

	Cents per pound.
Nitrogen in ammonia and nitrates	24
Nitrogen in Peruvian guano, fine steamed bone, dried and fine-ground blood, meat, and fish	20
Nitrogen in fine-ground bone, horn, and wool dust	18
Nitrogen in coarse bone, horn shavings, and fish scrap	15
Phosphoric acid soluble in water	12½
Phosphoric acid 'reverted' and in Peruvian guano	9
Phosphoric acid, insoluble, in fine bone and fish guano	7
Phosphoric acid, insoluble, in coarse bone, bone ash, and bone-black	5
Phosphoric acid, insoluble, in fine ground rock phosphate	3½
Potash in high-grade sulphate	9
Potash in kainit as sulphate	7½
Potash in muriate or potassium chloride	9

"These 'estimated values' are not fixed, but vary with the state of the market, and are from time to time subject to revision. They are not exact to the cent or its fractions, because the same article sells cheaper at commercial or manufacturing centers than in country towns, cheaper in large lots than in small, cheaper for cash than on time. These values are high enough to do no injustice to the dealer, and accurate enough to serve the object of the consumer. * * * The 'estimated values per pound' in the above schedule are similar to those employed by Dr. Goessmann and Professor Atwater in their recent reports."

This method of estimating the commercial values of fertilizers has been long practiced and has its uses, particularly as a forcible means of illustrating frauds, and as the first step in the process of educating farmers and manufacturers. People who are not familiar with chemical terms understand dollars and cents, and are much more impressed by a fertilizers "analyzing" $30 per ton when the price is $45, than by its containing only six per cent. of soluble phosphoric acid when it ought to have twelve.

These calculations are, however, open to serious objections, with the rest, because they not only differ very widely from the agricultural

values, but also in many cases decidedly misrepresent the commercial values. It is on this account that they have so generally fallen into disuse or been discarded in England and Germany.

For the present purpose, another method, which has been proposed in the Connecticut station reports, is more fitting. It consists in comparing the different materials by the costs of the ingredients per pound.*

So weighty a matter as this demands full consideration. I therefore give here a table, in which are stated the composition and prevailing market-price per ton, a considerable number of the more important commercial fertilizers in our markets, and the costs per pound of the nitrogen, phosphoric acid, and potash in each at the prices named. Those designated by Arabic numerals were analyzed under the writer's direction. The others are taken from dealers' price-lists. Where several prices are given for the same article, the lower ones apply to smaller and the higher to larger lots.

---

*See Appendix for details of method of these calculations and for tables of analyses of a number of commercial fertilizers.

Percentages and costs per pound of valuable ingredients of commercial fertilizers.

Fertilizing materials.	Number.	PERCENTAGES. Nitrogen.	PERCENTAGES. Phosphoric acid. Available. Soluble in water.	PERCENTAGES. Phosphoric acid. Available. Soluble in ammonium citrate.	PERCENTAGES. Phosphoric acid. Insoluble.	PERCENTAGES. Phosphoric acid. Total.	PERCENTAGES. Potash.	Retail price per ton.	COST PER POUND IN CENTS. Nitrogen.	COST PER POUND IN CENTS. Phosphoric acid. Soluble.	COST PER POUND IN CENTS. Phosphoric acid. Reverted.	COST PER POUND IN CENTS. Phosphoric acid. Insoluble.	COST PER POUND IN CENTS. Phosphoric acid. Total.	COST PER POUND IN CENTS. Potash.
NITROGEN.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Dolls.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Nitrate of soda, 95 per cent	I	15.65						70 00	22.4					
Do	I	15.65						75 00	24.0					
Do	I	15.65						80 00	25.6					
Do	I	15.65						85 00	27.2					
Do	I	15.65						90 00	27.8					
Nitrate of soda, 97.31 per cent	**163**	16.02						75 00	23.4					
Do	**163**	16.00						80 00	25.0					
Do	**163**	16.00						85 00	26.6					
Do	**163**	16.00						90 00	28.1					
Sulphate of ammonia, 24.29 per cent. ammonia	II	20.00						90 00	22.5					
Do	II	20.00						95 00	23.8					
Do	II	20.00						100 00	25.0					
Do	II	20.00						110 00	27.5					
Sulphate of ammonia, 24.90 per cent. ammonia	**3**	20.53						97 50	23.8					
Sulphate of ammonia, 24.92 per cent. ammonia	**161**	20.51						90 00	22.0					
Do	**161**	20.50						95 00	23.1					
Do	**161**	20.50						100 00	24.4					
Do	**161**	20.50						105 00	25.6					
Do	**161**	20.50						110 00	26.8					
Dried blood (counting phosphoric acid)	**160**	11.48				1.35		45 00	18.7				7.5	
Dried blood (not counting phosphoric acid)	**160**	11.48						45 00	19.6					
Do	**160**	11.50						50 00	21.7					
Dried blood, at \$3.50 per unit for ammonia	III								21.3					
Dried blood, at \$4.50 per unit for ammonia	III								24.28					

Percentages and costs per pound of valuable ingredients of commercial fertilizers—Continued.

Fertilizing materials.	Number.	PERCENTAGES.						Retail price per ton.	COST PER POUND IN CENTS.					
		Nitrogen.	Phosphoric acid.				Potash.		Nitrogen.	Phosphoric acid.				Potash.
			Available.		Insoluble.	Total.				Soluble.	Reverted.	Insoluble.	Total.	
			Soluble in water.	Soluble in ammonium citrate.										
PHOSPHORIC ACID—SOLUBLE.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Dolls.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Dissolved bone-black	IV		15.00					33 00		11.0				
Do	IV		15.00					35 00		11.7				
Do	IV		15.00					36 00		12.0				
Do	V		16.50					36 00		10.9				
Superphosphate, from South Carolina phosphate	VI		10.50	4.30				30 00		10.5	7.0			
Superphosphate, from Canada apatite	VII		15.00					30 00		10.0				
Superphosphate, from Philadelphia	VIII		31.00					65 00		10.5				
English superphosphate	**53**		23.28		8.67			61 00		11.5		4.6		
PHOSPHORIC ACID—INSOLUBLE.														
South Carolina rock phosphate	IX					26.00		20 00					3.8	
Navassa phosphate	**45**					20.45		20 00					4.9	
Caribbean Sea guano, orchilla	**125**					27.18		25 00					4.6	
Spent bone-black	X					32.00		26 00					4.1	
Do	X					32.00		30 00					4.7	
POTASH (POTASSA).														
GERMAN POTASH SALTS.														
Sulphate, 65 per cent	XI						35.15	55 00						7.8
Do	XI						35.15	60 00						8.5
Sulphate, 70 per cent	XII						37.86	60 00						7.9
Do	XII						37.86	65 00						8.6
Sulphate, 80 per cent	XIII						43.26	65 00						7.5
Do	XIII						43.26	70 00						7.8
Do	XIII						43.26	75 00						8.1

Do		XIII						43.26	80 00						8.4
Sulphate, 59.72 per cent		162						31.72	60 00						9.5
Sulphate, 75.19 per cent		184						40.66	65 00						8.0
Chloride (muriate) 80 per cent		XIV						50.54	45 00						4.4
Do		XIV						50.54	50 00						4.9
Do		XIV						50.54	55 00						5.4
Do		XIV						50.54	60 00						5.9
Chloride (muriate) 84 per cent		XV						53.06	50 00						4.7
Do		XV						53.06	55 00						5.2
Do		XV						54.06	60 00						5.7
Chloride (muriate) 80.08 per cent		33						50.64	60 00						5.9
NITROGEN AND PHOSPHORIC ACID.															
SLAUGHTER-HOUSE REFUSE.															
Meat scrap, Brighton abattoir		151	8.63				3.46		35 00	17.4				7.0	
Brighton animal fertilizer		153	6.53				11.90		40 00	17.7				7.1	
Brighton animal fertilizer, acidulated*		31	5.33	6.37		1.11			40 00	20.9	12.5		5.0		
Do		154	7.60	7.85	0.59				45 00	17.9	10.8	7.1			
Dried blood, meat scrap, and bone, Strong, Barnes, Hart & Co		102	8.08				5.20		40 00	19.7				7.9	
Do		102	8.08				5.20		30 00	14.8				5.9	
Do		142	9.72				3.83		40 00	17.8				7.1	
Do		142	9.73				3.83		30 00	13.3				5.3	
VEGETABLE REFUSE.															
Castor pomace		35	4.80				2.11		25 00	22.1				8.8	
Do		59	4.69				1.91		19 00	16.8				6.7	
Do		105	5.29				2.42		19 00	15.2				6.1	
BONE MANURES.	Grade of fineness.														
Ground bone, J. Lister	I	91	3.63				22.85		35 00	11.6				5.8	
Pure ground bone, L. B. Darling & Co	I	175	3.61				22.16		40 00	13.6				6.8	
Bone sawings, Granby Manufacturing Company	I	193	3.69				26.05		40 00	12.0				6.0	
Ground bone, Thompson & Edwards	II	181	2.67				26.08		35 00	11.2				5.6	
Ground bone, H. J. Baker & Bro	III	94	3.88				23.61		33 00	10.5				5.2	
Bone flour, P. W. Bennett	III	92	3.91				22.05		36 00	12.0				6.0	
Fine ground bone, G. W. Miller	III	93	3.88				21.95		36 00	12.0				6.0	
Ground bone, Peck Bros	IV	58	4.03				19.79		38 00	13.6				6.8	
Coarse ground bone, P. W. Bennett	IV	92a	3.91				22.05		30 00	10.0				5.0	
Coarse ground bone, G. W. Miller	VI	93a	3.88				21.95		30 00	10.1				5.0	
NITROGENOUS SUPERPHOSPHATES.															
Ammoniated bone superphosphate, Russell Coe		128	2.24	11.67	0.92	0.20			40 00	21.0	12.5	8.3	5.0		
Do		135	2.94	12.05	0.34	0.57			40 00	19.1	11.5	7.7	4.6		
Do		168	2.04	12.53	0.46				40 00	20.5	12.3	8.2			
Do		170	3.81	11.05	1.08				40 00	18.3	11.0	7.3			
Average of four samples above										19.7	11.8	7.9	4.8		

Percentages and costs per pound of valuable ingredients of commercial fertilizers—Continued.

Fertilizing materials.	Percentages.							Retail price per ton.	Cost per pound in cents.					
			Phosphoric acid.							Phosphoric acid.				
			Available.											
	Number.	Nitrogen.	Soluble in water.	Soluble in ammonium citrate.	Insoluble.	Total.	Potash.		Nitrogen.	Soluble.	Reverted.	Insoluble.	Total.	Potash.
NITROGEN AND PHOSPHORIC ACID.														
NITROGENOUS SUPERPHOSPHATES—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Dolls.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Soluble nitrogenous phosphate, Quinnipiac Fertilizing Company	**101**	4.41	7.24		0.46			40 00	22.7	13.6		5.4		
Do	**146**	3.33	8.16	3.39	2.55			40 00	19.6	11.8	7.8	4.7		
Do	**171**	2.49	7.65	2.29	1.91			40 00	23.6	14.2	9.5	5.7		
Average of three samples above									22.0	13.2	8.6	3.3		
Pine Island guano, Quinnipiac Fertilizing Company	**99**	5.64	4.95	2.32	1.93			45 00	22.5	13.5	9.0	5.4		
Do	**173**	6,25	4.93	0.96	0.84			45 00	23.0	13.8	9.2	5.5		
Average of two samples above									22.7	13.6	9.1	5.4		
FISH MANURES.														
Dry ground fish, Allen's	**24**	8.80				6.17		40 00	17.7				7.1	
Do	**185**	7.88				7.90		40 00	18.1				7.2	
Average of two samples, Allen's		8.34				7.03		40 00	17.9				7.2	
Dry ground fish, Quinnipiac Fertilizing Company	**100**	7.50				6.67		45 00	22.1				8.8	
Do	**140**	7.38				7.21		45 00	21.9				8.8	
Do	**172**	7.96				7.55		45 00	20.5				8.2	
Average of three samples, Quinnipiac Fertilizing Company		7.61				7.14		45 00	21.5				8.6	
Dry fish, unground, Green Bros	**179**	8.60				10.51		28 00	10.9				4.4	
Half dry fish scrap	**103**	5.33				6.23		16 00	10.2				4.1	
Do	**131**	5.49				7.49		16 00	9.4				3.8	
NITROGEN, PHOSPHORIC ACID, AND POTASH.														
PERUVIAN GUANOS.														
Ten per cent. ammonia standard	**47**	11.33	4.14	8.81	2.42		2.33	60 00	16.0	9.6	6.4	3.8		5.1
Do	**108**	8.56	5.25	9.79	2.86		3.24	60 00	17.3	10.4	6.9	4.2		5.5

Do	**137**	7.76	5.27	6.24	4.01	....	4.36	58 50	18.5	11.1	7.4	4.5	......	5.9
Do	**164**	7.52	6.05	5.59	1.39	....	4.61	57 00	18.9	11.3	7.6	4.5	......	6.0
Do	**191**	7.88	5.11	7.10	5.04	....	3.54	58 00	18.0	10.8	7.2	4.3	......	5.7
Average of eight samples as above	....	8.48	5.10	6.48	3.53	....	3.60	58 00	17.1	10.2	7.3	4.9	......	6.5
Guaranteed, cargo A	**186**	5.87	4.55	4.35	7.10	....	3.45	56 00	21.3	12.9	8.5	5.1	......	6.8
Do	**187**	5.79	4.50	5.11	7.49	....	3.36	56 00	20.9	12.5	8.4	5.0	......	6.7
Average of two samples above	....	....	....	....	....	....	....	....	21.1	12.7	8.45	5.55	......	6.75
Rectified	**57**	9.15	10.67	....	1.71	....	2.43	60 00	17.9	10.8	......	4.3	......	5.7
Do	**136**	7.82	10.02	2.82	....	....	4.34	65 00	19.9	11.9	8.0	......	......	6.4
Average of two samples above	....	....	....	....	....	....	....	....	18.9	11.35	8.0	4.3	......	6.05
Peruvian guano, Lobos	**243**	4.68	6.80	6.68	4.13	....	4.23	49 00	17.0	10.1	7.3	4.9	......	6.5
Peruvian guano, No. 2	**244**	2.60	4.01	7.81	2.12	....	2.67	39 50	19.8	11.8	8.5	5.7	......	7.6

Of the above figures it may be remarked:

1. The articles are of the higher grades. The poorer articles with which the markets are infested are not taken into account. The nitrogenous superphosphates, for instance, were among the best of about fifty samples from which the selections were made.

2. The costs of the ingredients vary widely in the different articles. This is illustrated by the following figures, which represent average market-rates:

Fertilizers.*	Costs per pound in cents.			
	Nitrogen.	Phosphoric acid.		Potash.
		Soluble.	Total.	
Nitrate of soda	24 to 25			
Sulphate of ammonia	24 to 25			
Dried blood	19 to 23			
Superphosphates		10 to 11		
Potash salts, sulphates				8
Potash salts, muriates				4¼ to 5
Slaughter-house refuse	15 to 20	10 to 12		
Bone manures, best	10 to 12		5 to 6	
Bone manures, medium	14 to 16		7 to 8	
Bone manures, inferior	18 to 24		9 to 12	
Nitrogenous superphosphates, best	18 to 21	11 to 12½		
Nitrogenous superphosphates, medium	24 to 28	14 to 16	5 to 8	
Nitrogenous superphosphates, inferior	30 to 40	18 to 24	6 to 12	
Peruvian guanos	17 to 21	10 to 12½		5½ to 6½
Dry ground fish guano	18 to 22		7 to 8½	
Dry fish-scrap	10 to 15		4¼ to 6	
Half-dry fish-scrap	7½ to 11		3¾ to 4¼	

Relative values of different fertilizers.—Fish and Peruvian guanos.

309. From these figures, which represent a somewhat extensive and thorough survey of the northern and eastern fertilizer markets, it appears that, taking into account composition and price, fish manures furnish the active manurial ingredients, nitrogen and phosphoric acid, at lower rates than any other commercial fertilizers except bone manures. But in bone, the fertilizing ingredients act more slowly. Taking the form of combination, the availability, into account, the nitrogen and phosphoric acid in bone can rival those of fish, only when they are wanted for slow and long-continued use, as in "seeding down" with grass.

Next in order of cheapness come Peruvian guanos. In fairness, however, these ought to be compared only with the dried and finely pulverized fish guanos. Indeed, a pound of nitrogen or phosphoric acid is doubtless worth on the average considerably more, agriculturally, in Peruvian guano than in even the driest and finest fish.

* As was remarked, the nitrogenous superphosphates in the table preceding this were the best of some fifty samples of a large number of brands analyzed at this place. In that list, and in those in the appendix, can be seen the data upon which the above figures are based. The analyses from which the tables are made up were made under the direction of the writer, into whose hands not far from three hundred samples of the commercial fertilizers in the Boston, New York, Philadelphia, and Baltimore markets have lately come for examination. Fraudulent articles are excluded from the computation.

This leads us to consider the values of nitrogen and phosphoric acid in different forms of combination. In general, it may be said that nitrogen is in its most readily available forms in sulphate of ammonia and nitrate of soda; that it becomes quickly useful to the plant in Peruvian guano, more slowly so in fish, dried blood, and meat scraps, and is very long in becoming available in leather scraps, hoof and horn shavings, hair, and the like. Soluble phosphoric acid is ready for use at once. The insoluble phosphoric acid of fish guano, meat, and finely steamed bones, acts more or less quickly, but in coarse pieces of bone and in bone black its action is very slow. In the South Carolina, Nevassa, Canada, and other mineral and fossil phosphates, it is of comparatively little value.

The nitrogen and phosphoric acid in coarse fish scraps are less valuable than in fine dry fish, for two reasons: they are more bulky to transport and apply, and are less available to plants when applied.

In 100 pounds of dry guano, there will be say, 10–15 pounds of water, while 100 pounds of half-dry scrap will contain 40–50 pounds of water. To get 100 pounds of dry matter will require on the average, say, 112 pounds of guano and 180 pounds of the half-dry scrap.

Again, the finely ground fish distributed evenly and thoroughly through the soil, is readily decomposed, and thus conveyed where the largest number of roots may have access to it and its materials will be available to the roots when they find it. But the coarse scrap cannot be as well distributed either when it is applied or by natural agencies afterward, less roots will get at it, and when they do find it they will not be able to use it as well as they could the more finely ground and better decomposed guano. Less of the coarse scrap will enure to the benefit of the first crop; and of that which is left over, the phosphoric acid will remain in the soil for subsequent crops, but more or less of the nitrogen will in the process of decomposition be set free and escape into the air, or be leached away by soil-waters beyond the reach of plants, or fixed in unavailable combinations in the soil and thus lost to vegetation.

A great deal has been said about the relative values of fish and Peruvian guano. The following table gives the results of experiments bearing upon this point. The experiments were made upon twenty different beet-sugar farms in and about Germany. The general plan and the details were the same for all. They were carried on by intelligent farmers, under the guidance of Dr. Grouven, director of the experiment station at Salzmünde in Prussia. The figures represent the value in German thalers of the increase in yield over unmanured plots, taking into account not only the increase of the manured crop, but the after effect during two succeeding years. The fish guano was the Norwegian,

which has more nitrogen and much more phosphoric acid than our fish guanos.

Manuring per Prussian morgen.	Gain over unmanured plots, in thaler, per morgen.				Cost of fertilizers per morgen.	Consequent gain from manuring.
	1862.	1863.	1864.	Increase for the three years over unmanured.		
	Fertilizers applied for sugar beets. Average of 20 fields.	No manure; grain and straw; after effect of manuring of 1862. Average of 13 fields.	No manure; sugar beets; after effect of manuring of 1862. Average of 12 fields.			
	Thaler.	*Thaler.*	*Thaler.*	*Thaler.*	*Thaler.*	*Thaler.*
1.6 cwt. Peruvian guano	12.7	2.9	3.9	19.5	7½	12.0
3.2 cwt. Peruvian guano	17.8	4.1	4.0	25.9	15	10.9
6.4 cwt. Peruvian guano	23.8	7.7	7.9	39.4	30	9.4
4 cwt. superphosphate	8.8	1.3	7.8	17.9	8⅔	9.2
6 cwt. superphosphate	9.7	2.4	10.1	22.2	13	9.2
8 cwt. superphosphate	10.6	1.3	8.9	20.8	17⅓	3.5
3 cwt. fish guano	7.7	0.3	2.5	10.5	9	1.5
6 cwt. fish guano	11.1	1.2	3.0	13.3	18	—2.7
1½ cwt. nitrate of soda	8.7	0.7	0	9.4	8	1.4
3 cwt. nitrate of soda	14.2	1.3	0	15.5	16	—0.5

The German thaler = 72 cents gold, nearly.
The German cwt. or centner = 111 pounds, nearly.
The German morgen = ⅔ acre, nearly.

Comparing the plots which had 3 cwt. each of fish and Peruvian guano it is to be observed that—

1. The Peruvian guano cost nearly twice as much as the fish guano.
2. The gain from the Peruvian guano, over and above the cost, was six times as much as that from the fish.

These results are remarkably favorable for the Peruvian guano. But it is to be noted that these experiments were on two crops of sugar-beets, with one of grain between. With other crops the results might have been very different.

Stoeckhardt, who has given as much attention to this matter as any one, infers, from a large number of field experiments made under his direction, that the fish guano is very nearly as effective as Peruvian.

Aside from its content of potash, of which fish has as good as none, the greater value of Peruvian guano, which is a fish product, must be due in the main to the fact that, as the result of the changes effected in its passage through the bird and subsequently, the ingredients have entered into new, simpler, and more available forms of combination. Taking into account composition, quality, and price, the cheapest fertilizers in the market are Peruvian guanos; next to these come fish manures.

Ways of improving fish manures.—Fermentation.

310. The advantage of these changes in the composition of fertilizers is much better appreciated in Europe than here. Several ways are recommended to bring them about. One of these is by fermentation.

The increasing importance of fish and bone manures in German agriculture has led Dr. Pagel, of the experiment station at Halle, to undertake a series of experiments to gain light upon the best means of preparing these for use. He recommends very strongly the plan of fermenting them with urine: "The method of fermentation furnishes a most excellent means for transforming the nitrogen in manures of organic origin, which is insoluble and slow in its action, into more soluble and consequently more active forms. It is hence peculiarly applicable to ground-bone and fish guano." He recommends to add about 30 quarts of urine to 100 pounds of bone or guano, and cover the heap with plaster (gypsum) or earth to prevent the escape of ammonia. If this is properly done, the mass will ferment, and the temperature rise to a little above 100° Fahr. The completion of the process, for which three or four weeks should suffice, is indicated by the cooling of the heap. Pagel found nearly one-half the nitrogen of fish to be made soluble in water by this process.

Composting fish fertilizers.

311. Another excellent method of utilizing fish is by composting. I can explain this in no better way than by referring to the experience of one of the most intelligent and successful farmers in our State, Mr. D., who lately called upon me to inquire about this subject. Mr. D.'s problem was simply how to get fertilizing materials for his soil in the best and cheapest manner. He proposed this question:

"I understand that the superphosphate manufacturers make their fertilizers of fish scrap and phosphates, treating them with oil of vitriol to make the phosphoric acid and nitrogen more available. Now can't I accomplish the same by composting in my barn-cellar? I understand the elements must go out of their original combinations into others before they can become useful to my plants, and that the acid and the manufacturing help this change along. I can get fish scrap for $17 per ton. Can I not bring this change about in a compost-heap, and will it not be a great saving to me?"

The answer was plain: "Fish scrap at $17 per ton will bring nitrogen at say 10 cents and phosphoric acid at 5 cents per pound. In "ammoniated" superphosphates, you will pay from 20 to 30 cents or more per pound for nitrogen, and from 8 to 20 cents per pound for your phosphoric acid."

"Do I need a phosphate with the scrap; if so, will bone be as good as anything? I can get ground bone from a g ue factory at $30 per ton."

"The bone at that price will give phosphoric acid at say 5 cents and

nitrogen at 10 cents per pound. If rightly composted the ingredients will become available speedily and surely. For most soils and crops the increased proportion of phosphoric acid which the bone would add would be very advantageous."

"I am persuaded that my soil wants potash. Should that be put in the compost; and, if so, what is the cheapest way to get it?"

"If you can get fresh ashes cheap they will do very well. If not, the 'muriate of potash,' which contains 50 per cent. 'actual potash,' and can be bought in the larger markets at $45 or less per ton, will be best. But the ashes have the advantage over the potash-salt that they supply all the ingredients of plant food but nitrogen, and further, by virtue of their large amount of lime and alkalies, they aid the decomposition of the matters in the compost very materially. In absence of ashes, lime will serve an excellent purpose."

Mr. D. explained his proposed method of composting, which consisted of mixing muck and mellow earth with the fish, bone, potash-salts, and lime, in alternate layers, in heaps where the urine from the stables would be caught and absorbed. From previous experience he believed that he could secure a moderately rapid fermentation which would keep the heap warm, but not too hot, and after a reasonable time have gone so far as to decompose the fragments of fish and bone and leave the whole heap in a well-rotted and uniform condition. I could only say that this seemed to me an extremely rational, sensible, and profitable way of making manure. And I cannot answer the numerous questions I receive about the best way of composting fish for manure any better than by giving the conversation with Mr. D. substantially as I recall it.

Improving fish for manure by feeding it to stock.

312. The most rational method of utilizing fish for manure, and the one which it seems to me must prove by far the most profitable way of economizing our waste fish products, is by feeding them to stock.

European farmers have learned in their practice what science has explained in theory, that just as the most reliable and useful manure is that produced in the stable and barn-yard, so this manure can be vastly improved by foods rich in nitrogen. English, French, and German farmers have found the feeding of oil cake and meal so profitable that manufacturers, entirely unable to meet the demand from the home supply, ransack the markets of Russia, India, and the United States to obtain it. Our linseed and cotton-seed products are in great demand for foreign export. After our oil manufacturers have pressed out the oil, whose value is well enough understood in the commerical world to keep it at home, the press cake, whose worth our farmers have not yet learned, is sent abroad to enrich the cattle food, manure, and purses of foreign farmers who know what it is good for and how to use it.

What gives the value to these waste products is chiefly their nitrogen compounds.

Of late the importance of animal wastes, flesh, meal, dried blood, and fish has come to be understood, and a good many accurate experiments have been made to test their digestibility, their nutritive value, and that of the manure produced from them. This will be explained in the following section, paragraphs 314–325. I will here only refer in few words to the results of a late series of experiments by Wildt, at Proskau, and by Kellner, at Hohenheim, with Norwegian fish guano fed to sheep. It appears that sheep digest the most of the nitrogenous material of the flesh, and a large part of that of the bone. What is not stored away in the body of the animal is excreted as urea, one of the most valuable forms of nitrogen for plant food. Only a small part of the phosphoric acid is digested, but the remainder is left in a very finely divided form, and hence much better for a manure. Kellner discusses the various methods employed for making the ingredients of fish more available for manure. Treatment with acid and caustic alkalies is unsatisfactory. Fermentation with urine is much better; but the most convenient and profitable way he concludes to be that of passing it through the digestive organs of domestic animals.

Practical conclusions.

313. One very great obstacle to the profit from using fish as manure is the fact that it contains only nitrogen, phosphoric acid, and lime, and does not supply the other soil ingredients of plant-food. Where potash is wanted the fish cannot suffice. Illustrations of this are only too abundant. I have only to look out of the window where I write to see in the distance a farm whose proprietor, some time ago, applied fish to one of his fields at the rate of nearly a ton to the acre, hoping to obtain a good crop of hay. In spite of this heavy and costly dressing the grass failed. At my suggestion he tried a series of experiments with different fertilizers to test the deficiencies of his soil. Wherever potash salts were used the crop was good; without potash it failed. The best results were obtained with a "complete" fertilizer, containing nitrogen, phosphoric acid, and potash, such as could be made from fish and potash salts. The recognition of facts like this often makes the difference between good profit and ruinous failure in farming.

The large amount of nitrogen in fish makes it a "stimulating" manure. It helps crops to get more of the food contained in the soil, and thus to "exhaust" the immediately available supply. Farmers often complain that fish, like Peruvian guano, wears out their land. In Maine they talk of land that has been "herringed to death." In Connecticut we often see grasses leaving and sorrel coming in after such fertilizers are used. Some good farmers say their soil gets hard and "caked" after continuous use of fish. The remedies are, tillage and use of other manures, ashes, lime, potash salts, bone, yard manure, muck, and so on.

The nitrogen in fish makes it particularly good for grass and grain, but excess is apt to make grain "run to stalk" and lodge, and may injure or even kill any crop for which it is used.

Besides grain and grass crops, fish does well for corn, potatoes, garden vegetables, etc. It promotes the growth of tobacco, but is thought by many farmers to injure the quality of the leaf.

The fine, dry fish-guano with little oil is the best. The coarse, wet scrap is inconvenient to handle, and cannot be well diffused through the soil. Concentrated fertilizers ought to be thoroughly mixed with the soil so as to be accessible to the largest number of roots and injure none. Neglect to observe this causes immense waste of fertilizing materials and loss of crops. If the coarse scrap is to be used it is best to compost it. The lumps are thus divided, the material decomposed and changed to more available forms, its value for plant-food increased, and it can be applied so as to secure the greatest benefit with the least waste.

Fermentation with urine, as described above, improves fish greatly.

The best method of all for getting fish into forms most fit for plant-food is to feed it to stock. This brings a two-fold advantage: it supplies the nitrogen (protein albuminoids) that poor foods, such as straw, cornstalks, and poor hay lack, and makes excellent fodder from cheap materials, while the nitrogen and phosphoric acid that are not used at the greatest possible profit to make flesh and bone are left in the manure in much better form for plant-food than they were in the fish.

There is great need of improvement in the manufacture of fish manures. What is wanted is a fine, dry product with as little ballast of water and oil and as much nitrogen as possible.

The chief obstacle to the better economizing of fish in agriculture is lack of information as to the best ways of making and using the products. To get this, careful scientific research and close practical observation are indispensable. Investigations in the laboratory and experiments in the field combined will bring the needed knowledge, and it will be worth a hundred times the cost.

52. Fish as food for domestic animals.

Principles of animal nutrition.—European experiments.

314. Undoubtedly the manure problem is the most important that the agriculture of our older States has to solve. The next weightiest is the food question, how to best economize and improve our fodder materials. Inside this the most important special problem is how to obtain foods rich in nitrogen. Our feeding materials, taking them together, lack nitrogen. In consequence, our animals are insufficiently fed and fail to get the full benefit of the food they do have. The result is underproduction of meat, dairy products, and work, and in turn poor manure and poor crops. European farmers have passed through this costly

and bitter experience ahead of us, and have learned the cause and the cure. Necessity has driven them to study these problems in ways of whose cost, extent, and beneficent results we on this side of the water have as yet only a faint conception. Hundreds, we might almost say thousands, of feeding experiments have been made with horses, oxen, cows, sheep, goats, swine, and other animals. Some of the ablest chemists and physiologists in Europe are devoting their lives to these special investigations. Governments, universities, agricultural schools, societies, and private individuals are giving money by hundreds of thousands of dollars for the work. In the last ten or fifteen years investigation has been especially active. In twenty agricultural experiment stations, and in a large number of laboratories of universities and other schools, the studies are being carried on to-day, and already definite knowledge has been obtained which many thousands of farmers on the other side of the Atlantic are using to their profit, is beginning to come to us and will, with what must be added by our own efforts, prove of inestimable value to our agriculture.

The lessons our foreign brethren have learned so dearly are free to us if we are wise enough to take and use them. Their substance is briefly this:

The advanced agriculture of the present day looks upon the farm or the stable as a sort of manufacturing establishment. Domestic animals are the machines, food in the form of hay, grain, root crops, commercial food materials, &c., are the raw materials, and meat, milk, wool, labor, and progeny the products.

In cattle-feeding, then, the important question is, how, with the foods at hand or obtainable, to get the most valuable product with the least outlay for raw material.

Feeding for maintenance and production.—Ingredients of foods and their functions.

315. Suppose that I have in my stable a cow, standing idle and giving no milk. She will require only food enough to supply the wastes resulting from the changes that are continually taking place in her internal organism, from the continual building over and renewal of all parts of her body. A certain amount of food of a certain quality is necessary, then, to *maintain* her in good " store " condition. This she will need to "hold her own" when nothing else is required of her.

But suppose that I demand of my cow *production*, say in the form of milk. For this purpose she will need more food. And, as everybody knows, the cow should have for the production of milk, not only a larger quantity, but also different quality of food from that which is needed for maintenance alone.

If, instead of milking my cow, I wish to fat her for the butcher, I shall also require production, but of still another sort, of fat and flesh. And if, instead of a cow, I have an ox that is to be kept at work, yet another

kind of production is required, muscular force. And I need not say that for these different kinds of production different kinds and amounts of fodder are requisite.

In the light of modern experimental science the maintenance of the animal and the production of meat, milk, heat, and force are not matter of so much hay, grain, and roots, but of the gluten, sugar, starch, fat, and so on, of which these are composed.

It has been already explained that animal and vegetable substances are composed of water, organic matters, and ash.

The following is, for instance, what is found in 100 pounds of wheat (grain):

		Pounds.
Water		13.5
Organic substances:		
Gluten, fibrin, &c. (containing nitrogen)		13.2
Starch	containing no nitrogen.	59.5
Sugar		2.4
Gum and other extractive matter		4.7
Fiber (cellulose)		3.0
Fatty matters (containing no nitrogen)		1.6
Mineral matter (ash)		2.1
Total		100.0

Corn, hay, potatoes, in fact vegetables generally, contain nearly the same list of ingredients as wheat, but in different proportions. The same is true of animal foods. Meat and milk consist of similar ingredients.

For our present purpose we have to consider only the organic substance. Now notice in the table above that there is a distinction between two classes of ingredients of this organic substance of wheat. The gluten and fibrin contain nitrogen, while the sugar, starch, fiber, fat, &c., contain no nitrogen.

This distinction between the nitrogenous and non-nitrogenous food ingredients is a fundamental one in economical cattle feeding.

Albumen, found pure in the white of an egg, is a representative of several kinds of substances, which consist chiefly of carbon, oxygen, hydrogen, and nitrogen. To these nitrogenous materials we apply the general name, albuminoids. The albuminoids are found in all animals and plants. Muscle or lean meat, casein (curd) of milk, fibrin of blood, gluten, albumen, and fibrin of plants, are examples. Clover, beans, pease, oil-cake, are rich in albuminoids.

Again, there are other animal and vegetable materials that consist of carbon, oxygen, and hydrogen, simply. These are called carbohydrates and fats. Starch, sugar, gum, and cellulose or fiber are carbohydrates. The oily and fatty matters of plants as well as butter, tallow, &c., are fats. Potatoes, sugar-beets, fodder-corn, and straw are rich in carbohydrates and poor in albuminoids.

The distinctions between the ingredients of the animal tissues and

products are similar. Lean meat or muscle and the casein (curd) of milk, like the albumen of the egg, are albuminoid substances and contain nitrogen. The fat of the body and the fat (butter) in the milk, like the oils and fats of plants, contain no nitrogen.

The ingredients of the body are built up from those of the food. The nitrogenous materials, muscle, connective tissue, skin, &c., are formed from albuminoids. The carbohydrates and fats of the food, which have no nitrogen, cannot be transformed into nitrogenous tissues of the body.

To form the fats, both the fats and albuminoids of the food contribute. A large part of the fat meat stored in the body and of the butter given off with the milk is made and must be made of the albuminoids of the food.

Just what work the carbohydrates do in the animal economy is not yet fully settled. They certainly cannot make flesh, and probably do but little at most to make fat. They act as fuel to keep up the animal heat, and doubtless contribute to the generation of muscular force. Just how much of the heat and force produced in the body comes from the consumption of albuminoids, how much from carbohydrates, and how much from fats is still an unsettled problem.

The animal has been compared to a machine. It is, however, a machine that must be kept running whether it produces anything or not. A horse, or cow, or sheep needs food even at rest in the stall. The machine is peculiar also in that it is wearing out continually and very rapidly, and consumes its own material for both fuel and repairs. The tissues of the body are all the while being used up and rebuilt. In the process of using up, heat and force are produced. The animal consumes food to make its flesh and fat and to give it warmth and strength, but it gets warmth and strength from the consumption of its own flesh and fat at the same time.

Now to make up for the continued wasting away of tissues and to maintain the supply of heat, food is necessary. But for this purpose but little of albuminoids is required. Carbohydrates will serve for fuel to keep the body warm. The horse or sheep at rest will get on with comparatively little nitrogen. Maintenance fodder may be poor in albuminoids if it furnish carbohydrates in plenty. Stock may be kept in the barn and even wintered on poor hay, cornstalks, and straw. But when production is required the case is very different. To make lean meat the animal must have albuminoids. Fat meat may be produced from the fat of the food, if there be enough, but practically a large part of the fat must come from albuminoids. The casein and fat (butter) of the milk likewise come from the albuminoids of the food, and for work also more or less of albuminoids are used. The growing colt or lamb, the working horse or ox, the milch cow and the fattening sheep or swine or steer must all have rich food and food rich in nitrogen. The nitrogenous ingredients, the albuminoids of the food, are its most important constituents. They may take the place of the carbo-

hydrates and fats to considerable extent, but their peculiar work must all be done by themselves. Such is the concurrent testimony of a vast amount of experimenting.

Again, of the whole ration consumed only a portion is digested and used to supply the animal's wants; the rest is voided as excrement, and valuable only for manure. It is important, then, that as much should be digested as possible. The value of the food will depend upon the amount the animal digests from it.

Economy in feeding requires, then, that the greatest amount of food be digested, and that this digested material contain sufficient albuminoids.

An excessive proportion of albuminoids is, however, uneconomical. The albuminoids are the costliest parts of the foods. No more should be used than necessary.

Proper proportions of digestible albuminoids, carbohydrates, and fats in the food are the chief requisites of economical feeding.

Digestion of foods by animals, as tested by European experiments.

316. The digestibility of different foods and food mixtures by different animals under varying circumstances has been tested by a very large number of experiments in the German experiment stations. The method consists in feeding animals with rations of known amount and composition, carefully collecting, weighing, and analyzing the excrements, the undigested portion, and subtracting the latter from the former. The following examples will serve for illustration:

In the stables of the station at Weende, under the direction of Professor Henneberg, two full-grown oxen were fed during one period of about two weeks with oat straw, during another period with bean straw, a third with clover hay, a fourth with meadow hay, and so on. During some of these periods a small amount of bean meal was added. The ration was at all times such as to keep the animals in fair and uniform condition. Careful weighings and analyses were made of fodder and excrement, that is to say, of the total and the undigested material, and from these the digestibility of the food was calculated. For instance, in one of the experiments of this series the ox consumed daily 16.9 pounds of meadow hay, or what is called here "English grasses."

There was contained in—	Organic dry substance.	Consisting of— Albuminoids.	Crude fiber.	Other carbohydrates.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
16.9 pounds of meadow hay	14.27	2.12	3.80	6.48
Excrement from same	6.33	.77	1.63	2.06
There was then digested	7.94	1.35	2.17	4.42

In another experiment the daily ration consisted of 17.87 pounds of oat straw, and 1.82 pounds bean meal.

There was contained in—	Organic dry substance.	Consisting of—		
		Albuminoids.	Crude fiber.	Other carbohydrates.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
17.87 pounds of oat-straw	14.27	1.12	6.41	6.74
Of this was digested	7.10	.58	3.64	2.88

The first digestion experiments were made some twenty years ago by Henneberg and Stohman, in the experiment station at Weende in Hanover. Their example has been followed in other places. Four years ago the number of digestion experiments amounted to over one thousand, and they have been increasing rapidly in numbers every year since then. These experiments, each one of which has been conducted with an amount of labor and exactness never equaled by a single experiment in this country, have led to many very interesting and weighty results.

What is essential to economy in feeding.—Albuminoids and carbohydrates.

317. The following are among the most important for our present purpose:

1st. Poor foods, like marsh-hay, late-cut hay, straw, cornstalks, and chaff, contain good percentages of digestible material. Their low feeding value is due, not to their lack of nutritive substance, but to its poverty in nitrogen. By adding to them concentrated foods rich in nitrogen, like oil-cake, cotton-seed, bean and pea meal, or nitrogenous animal matters, such as meat scrap and fish, rations are made equal in every respect to the best grass, young-cut hay, or grain.

2d. The digestion of foods, particularly of mixed rations, depends upon the proportions of its constituents. With too little nitrogen the digestion is incomplete. Adding concentrated foods rich in nitrogen to coarse foods promotes digestion. Excess of carbohydrates decreases it. Oil-cake, meat scrap, or fish added to poor hay or straw secures the most complete digestion of the whole ration. But if potatoes or other starchy food are used in considerable quantity the less of the coarse food will be digested.

There is still another principle of great importance to be noted. Well-manured plants are much richer in albuminoids than poorly manured. Bountiful fertilizing not only increases the quantity of the crop but improves its quality also.

The farmer who keeps his land in good condition gets larger yields; the produce contains more digestible substance for his stock, and the nutritive material is richer in the most valuable ingredients of all, the albuminoids.

Composition and valuations of various food materials.—German tables.

318. Fuller details and tables illustrating the principles here presented, may be found in a series of articles on science applied to farming, in the "American Agriculturist" for 1874–'76, and in a lecture on "The Results of Late European Experiments on the Feeding of Cattle," in the report of the Connecticut Board of Agriculture for 1874. A briefer statement of the subject is given by Prof. S. W. Johnson in the report of the Connecticut Agricultural Experiment Station for 1877. This latter contains a table which is interesting as including, with German analyses and valuations, some analyses of American products; with the rest, two samples of fish-scrap. The table is explained by Professor Johnson as follows:

"The following table of the composition, content of digestible nutritive ingredients, and money value of a few of the most important feeding-stuffs, is taken from the German of Dr. Emil Wolff, of the Agricultural Academy at Hohenheim, and represents the most recent and most trustworthy knowledge on these subjects.*

"The composition of feeding-stuffs, as here stated, is the average result of the numerous analyses that have been made within twenty-five years, mostly in the German experiment stations.

"The quantities of digestible ingredients are partly derived from actual feeding experiments and are partly the result of calculation and comparison.

"The percentages of the three classes of digestible matters, viz, albuminoids, carbohydrates, and fat, form the basis for calculating the money value of feeding-stuffs. The values attached to them by Dr. Wolff are the following, the German mark being considered as equal to 24 cents, and the kilogram equal to 2.2 pounds avoirdupois:

"1 pound of digestible albuminoids is worth $4\frac{1}{3}$ cents.

"1 pound of digestible fat is worth $4\frac{1}{3}$ cents.

"1 pound of digestible carbohydrates is worth $\frac{9}{10}$ of a cent.

"These figures express the present relative money values of the respective food-elements in the German markets. Whether or not these values are absolutely those of our markets, they represent presumably the *relative* values of these elements approximately, and we may provisionally employ them for the purpose of comparing together our feeding-stuffs in respect to money value. These money or market values are to a degree independent of the feeding values. That is, if of two kinds of food, for example Hungarian hay and malt sprouts, the one sums up a value of $0.66 and the other a value of $1.31 per hundred, it does not follow that the latter is worth for all purposes of feeding twice as much as the former, but it is meant that when both are properly used, one is worth twice as much money as the other. In fertilizers we estimate the nitrogen of ammonia salts at 24 cents per pound, and solu-

* From "*Mentzel u. Lengerke's Kalender,*" for 1878.

ble phosphoric acid at 12½ cents; but this means simply that these are equitable market prices for these articles, not that nitrogen is worth twice as much as soluble phosphoric acid for making crops. In the future more exact valuations may be obtained from an extensive review of the resources of our markets, in connection with the results of analyses of the feed and fodder consumed on our farms.

"The column headed 'Nutritive ratio' in the table gives the proportion of digestible albuminoids to digestible carbohydrates, inclusive of fat.* * * * To allow of directly comparing the money value of feeding-stuffs with some universally accepted standard, the last column gives a comparison with good average meadow hay taken as 1."

Average composition, digestibility, and money value of feeding-stuffs, as given by Dr. Wolff for Germany for* 1878.

Feeding-stuffs.	Water.	Ash.	Albuminoids.	Fiber.	Carbohydrates.	Fat.	Digestible matters.			Nutritive ratio.	Money value.	
							Albuminoids.	Carbohydrates.	Fat.		Dollars per 100 pounds.	Comparison with meadow hay=1.
Meadow hay, inferior	14.3	5.0	7.5	33.5	38.2	1.5	3.4	34.9	0.5	10.6	0.48	0.74
Meadow hay, better	14.3	5.4	9.2	29.2	39.7	2.0	4.6	36.4	0.6	8.3	0.55	0.86
Meadow hay, average	14.3	6.2	9.7	26.3	41.4	2.5	5.4	41.0	1.0	8.0	0.64	1.00
Meadow hay, very good	15.0	7.0	11.7	21.9	41.6	2.8	7.4	41.7	1.3	6.1	0.74	1.17
Meadow hay, extra	16.0	7.7	13.5	19.3	40.4	3.0	9.2	42.8	1.5	5.1	0.84	1.32
Clover hay, average	16.0	5.3	12.3	26.0	38.2	2.2	7.0	38.1	1.2	5.9	0.69	1.08
Clover hay, best	16.5	7.0	15.3	22.2	35.8	3.2	10.7	37.6	2.1	4.0	0.88	1.39
Timothy hay	14.3	4.5	9.7	22.7	45.8	3.0	5.8	43.4	1.4	8.1	0.69	1.09
Hungarian hay	13.4	5.7	10.8	29.4	38.5	2.2	6.1	41.0	0.9	7.1	0.66	1.04
Rye straw	14.3	4.1	3.0	44.0	33.3	1.3	0.8	36.5	0.4	46.9	0.35	0.55
Oat straw	14.3	4.0	4.0	39.5	36.2	2.0	1.4	40.1	0.7	29.9	0.44	0.69
Rich pasture grass	78.2	2.2	4.5	4.0	10.1	1.0	3.4	10.9	0.6	3.6	0.27	0.42
Average meadow grass, fresh	70.0	2.1	3.4	10.1	13.4	1.0	1.9	14.2	0.5	8.1	0.22	.36
Green maize, German	85.0	1.0	1.2	4.7	7.6	0.5	0.7	7.4	0.2	11.3	.10	.16
Green maize, Mr. Webb, 1874	86.0	0.8	0.8	4.8	7.3	0.3	0.6	8.3	0.2	14.4	.11	.17
Cured maize fodder, Mr. Webb	27.3	4.2	4.4	25.0	37.9	1.3	3.2	43.4	1.0	14.4	.57	.91
Potatoes	75.0	0.9	2.1	1.1	20.7	0.2	2.1	21.8	0.2	10.6	.29	.46
Mangolds	88.0	0,8	1.1	0.9	9.1	0.1	1.1	10.0	0.1	9.3	.14	.22
Rutabagas	87.0	1.0	1.3	1.1	9.5	0.1	1.3	10.6	0.1	8.3	.15	.24
Sugar beets	81.5	0.7	1.0	1.3	15.4	0.1	1.0	16.7	0.1	17.0	.19	.30
Maize, German	14.4	1.5	10.0	5.5	62.1	6.5	8.4	60.6	4.8	8.6	1.10	1.73
Maize meal, American, II	12.9	1.2	8.7	1.8	71.9	3.5	7.3	68.3	2.6	10.2	1.04	1.69
Oats	14.3	2.7	12.0	9.3	55.7	6.0	9.0	13.5	4.7	6.1	.97	1.53
Malt sprouts	10.1	7.2	24.3	14.3	42.1	2.1	19.4	45.0	1.7	2.5	1.31	2.06
Wheat bran, coarse	12.9	6.6	15.0	10.1	52.2	3.2	12.6	42.6	2.6	3.9	1.04	1.63
Wheat bran, fine	13.1	5.4	14.0	8.7	55.0	3.8	11.8	14.3	3.0	4.4	1.03	1.62
Middlings	11.5	3.0	13.9	4.8	63.5	3.3	10.8	54.0	2.9	5.7	1.07	1.68
Cotton-seed cake decorticated	11.2	7.6	38.8	9.2	19.5	13.7	31.0	18.3	12.3	1.6	2.05	3.22
Fish-scrap, by Goodale's process	11.5	....	64.0	....	......	4.6	57.6	......	4.1	0.2	2.67	4.17
Fish-scrap, dry ground	11.7	....	51.5	....	......	8.1	46.4	......	6.2	0.3	2.28	3.56
Dried blood	12.0	4.1	80.8	....	2.6	0.5	54.1	2.6	0.5	......	2.39	3.76
Whey	92.6	0.7	1.0	....	5.1	0.6	1.0	5.1	0.6	6.6	.11	.18
Milk	87.5	0.7	3.2	....	5.0	3.6	3.2	5.0	3.6	4.4	.34	.53

* Except those in italics, which are American products analyzed under direction of Professor Johnson.

Comparing the poorer foods, such as straw, cornstalks, and inferior hay with a good standard food like the best hay or pasture grass, it appears that the great difference is that the former lack albuminoids, just what bran, oil cake, cottonseed cake, and especially fish, supply. One

* Fat and carbohydrates have, it is believed, similar nutritive functions, and it is assumed that 1 part of fat equals 2.4 of carbohydrates.

hundred pounds of the fish scrap made by Goodale's process added to 900 lbs. of the poorest hay would make a mixture equal in composition to 1,000 pounds of the best hay. Three hundred pounds of the same fish-food with 1,700 lbs. of oat straw would be equal to a ton of the best hay.

It is clear, then, that what our farming wants, to make stock-raising profitable, manure plenty and rich, and crops large and nutritious, is nitrogenous material for foods.

One of the cheapest, most useful, and best forms in which this can be furnished is in fish products. In proof of this we have the testimony of both extensive experience and accurate experimenting.

Experience in use of fish as food for stock.—Feeding cattle on fish in Massachusetts.

319. The earliest account which I have met of fish as food for domestic animals is the following extract from the Barnstable [Mass.] "Journal," of February 7, 1833:

"*Feeding cattle on fish.*—The cattle at Provincetown feed upon fish with apparently as good relish as upon the best kinds of fodder. It is said that some cows, kept there several years, will, when grain and fish are placed before them at the same time, prefer the later, eating the whole of the fish before they touch the grain. Like one of old, we were rather incredulous on this subject, till we had the evidence of ocular demonstration. We have seen the cows at that place boldly enter the surf, in pursuit of the offals thrown from the fish-boats on the shore, and when obtained, masticate and swallow every part except the hardest bones. A Provincetown cow will dissect the head of a cod with wonderful celerity. She places one foot upon a part of it, and with her teeth tears off the skin and gristly parts, and in a few moments nothing is left but the bones."

The inhabitants of Provincetown are not the only people who feed their cattle upon fish. The nations of the Coromandel coast, as well as in the other parts of the East, practice feeding their flocks and herds with fish. The celebrated traveler, Ibu Batuta, who visited Zafar, the most easterly city in Yemen, in the early part of the fourteenth century, says that the inhabitants of that city carried on a great trade in horses in India, and at that period fed their flocks and herds with fish, a practice which he says he had nowhere else observed.

Experiment of Mr. Lawes, in England, with fish as food for swine.

320. In 1853 Mr. J. B. Lawes, of Rothamshead, England, reported several extensive series of experiments "On the Feeding of Pigs," in which were tested the effects of bean, lentil, Indian corn, and barley meals, bran, and dried Newfoundland codfish as foods for fattening and making manure. In speaking of the series in which the fish was fed with maize, barley, and bran in different proportions, Mr. Lawes says:

"In the series * * * where we have * * * a comparatively

small amount of non-nitrogenous matter consumed, the food consisted in a large proportion of the highly nitrogenous codfish; and in both of these cases we had not only a very good proportion of increase to food consumed, but the pigs in these pens were very fat and well ripened; and hence a large proportion of their increase would be real dry substance. * * * This result is in itself interesting, and it may perhaps point to a comparatively greater efficiency in the already animalized proteine compounds supplied in the codfish than in those derived, as in the other cases, from the purely vegetable diets."*

Other European experience.

321. In 1856 Professor Stoeckhardt, of Tharand, Saxony, who was one of the first chemists to recognize the value of fish guano, and has done more than any other one in Europe to encourage its manufacture and use, received a sample from Norway, which, as he says, "looked so inviting that I tried it for fodder also." He fed it to a half-year-old pig, which "did exceptionally well on this northern food."

In the northern part of Norway, when during the long winters the supply of hay and straw gives out, cattle are fed upon dried fish. They do poorly on this diet alone, of course, but recover very quickly when the spring pasturage comes.†

Success of Maine farmers in feeding fish to sheep.

322. The value of fish as food for domestic animals has been attested by experience of intelligent farmers in our own country, as is illustrated by the following extracts from Boardman and Atkins' report, from which so many quotations have already been made:

"As early as 1864, if not in fact previous to that date, the attention of members of the board of agriculture [of Maine], and farmers generally, was called to the matter of the value of fish pomace or scrap as a feeding stuff for sheep, swine, and poultry. In a communication to the board‡ Mr. William D. Dana, of Perry, spoke in high terms of its value as a feed for domestic animals, in which he said: 'Fish pomace, or the residuum of herring after the oil is pressed out, is greedily eaten by sheep, swine, and fowl; and probably pogy chum would be eaten as well. Smoked alewives and frost fish also furnish a food palatable to cattle. Sheep thrive well, get fat, and yield heavier fleeces when fed on this pomace than when fed on anything else produced in this section of the State. Careful and observing farmers, who have fed it, assert that it is of equal value with good hay, ton per ton, and that its value for manure is in no degree diminished by passing it through the living mill, and thus reducing it to a much more convenient state for applying. If it could be sufficiently dried, without other substances, to prevent putre-

* Jour. Roy. Ag. Soc., 1st Ser. XIV, 1853, p. 527.

† Meinert. Travels in Norway. Chem. Ack., 1870, xi, p. 45.

‡ Agriculture of Maine, 1864, p. 43.

faction, it would form a valuable article of cattle-feed in regions from which it is now excluded by the expense of transportation and its own odoriferous nature.'

"In remarking upon this the secretary of the board said that if sheep would eat the scrap readily, much poor hay or straw could be used to good advantage, thus allowing the farmer to consume all his first-quality hay in keeping other stock. He thought the meat would not taste of the flavor imparted by the scrap, provided other food was substituted for a proper length of time before slaughtering.

"From time to time following this, the matter was discussed before the board, and formed the subject of many articles in the agricultural journals. In 1869, Mr. M. L. Wilder,* of Pembroke, then a member of the board, presented a brief paper embodying his experience in the use of scrap as a feed for sheep, in which he said he believed 'fish offal to be not only cheaper, but much superior to any other kind of provender he had ever used' for this purpose. An extract from his paper is given: 'I keep about one hundred sheep, and have fed fish offal to them for the past ten years. The offal is made from herring caught in weirs, salted the same as for smoking, cooked, and the oil pressed out, leaving a pomace for which the sheep are more eager than for grain. For the last three winters I have kept my sheep on threshed straw with one-half pound per day to each sheep of dried fish pomace, or one pound of green (as it shrinks one-half in drying), and they came out in the spring in much better condition than when fed on good English hay with corn. I consider the dry pomace worth as much as corn, pound for pound. When I have had enough to give them one-half pound per day, I have found that the weight of the fleece was increased one-quarter, and not only that but also the carcass in a like proportion; the weight of the fleeces per head averaging from five to seven pounds.'

"Similar statements to the above were made by Hon. Samuel Wasson† and other gentlemen, not only at public meetings of the board, but through the press, so that the subject has been kept alive and invested with some interest down to the present time.

Experiments of Professor Farrington on fish scrap vs. corn meal as food for sheep.

"323. Wishing to test the value of scrap as a feed with more care than had apparently attended any of the trials that had been reported, and also wishing to make a sort of competitive trial of it in connection with corn, a quantity was obtained for this purpose of Mr. M. L. Wilder, of Pembroke. It was herring scrap, salted before the oil was expressed, and packed in barrels directly from the press, each barrel containing about 220 pounds. Its cost in Augusta, including freight from Pembroke via Portland, was not far from $2 per barrel.

*Agriculture of Maine, 1869, p. 60.

†Agriculture of Maine, 1874-'75, p. 1.

"This scrap was placed in the hands of Mr. J. R. Farrington, the instructor in agriculture at the State College, Orono, with the request that he would feed it to sheep in connection with Indian corn in such way as would best serve the purpose of ascertaining its comparative value as a provender or feed. Few instructions were given him, and he being left to carry out the experiment in his own way—and public acknowledgment should here be made for his interest in undertaking the matter, and for the care and faithfulness with which the experiment was conducted. The report of Mr. Farrington follows:

"'The statement made by a prominent agriculturist that for feeding sheep fish chum was equal to corn, pound for pound, furnished the basis for the experiment which we conducted to ascertain the comparative value of corn and fish chum when fed to sheep. Ten lambs, dropped the previous spring, were selected; each one was designated by a number, the number being stamped on a metallic tag and attached by a copper wire to the ear of the lamb; Nos. 1, 2, 3, 4, and 5 constituted flock 1; Nos. 6, 7, 8, 9, and 10, flock 2. We began feeding January 15, 1875. Flock No. 1 was fed with corn; flock No. 2 was fed with fish. Each flock was given what good hay it would eat. The hay fed to each flock during the month (four weeks) beginning February 13 was weighed. Flock No. 1 ate, in four weeks, 335 pounds; flock No. 2 ate 338 pounds.

"'At commencement of feeding, January 15, 1875:

Flock No. 1 weighed as follows:

Sheep No. 1 weighed	46 lbs.
" 2 "	77 "
" 3 "	67 "
" 4 "	55 "
" 5 "	68 "
Weight of flock, Jan. 15	313 "

Flock No. 2 weighed as follows:

Sheep No. 6 weighed	49 lbs.
" 7 "	74 "
" 8 "	68½ "
" 9 "	67 "
" 10 "	58 "
Weight of flock, Jan. 15	316½ "

During four weeks ending February 13, 18¼ pounds of corn were fed to flock No. 1. At this date—

Sheep No. 1 weighed	50 lbs., a gain of	4 lbs.
" 2 "	81½ "	4½ "
" 3 "	73 "	6 "
" 4 "	59 "	4 "
" 5 "	77 "	9 "
Weight, February 13	340½ "	27½ "

During four weeks ending February 13, 18¼ pounds of fish were fed to flock No. 2. At this date—

Sheep No. 6 weighed	52 lbs., a gain of	3 lbs.
" 7 "	81 "	7 "
" 8 "	72½ "	4 "
" 9 "	68 "	1 "
" 10 "	64½ "	6½ "
Weight, February 13	338 "	21½ "

During four weeks ending March 12, 20 pounds of corn and 335 pounds of hay were fed flock No. 1. At this date—

Sheep No. 1 weighed	50½ lbs., a gain of	½ lbs.
" 2 "	75½ lbs., a loss of	6 "
" 3 "	69 "	4 "
" 4 "	56½ "	2½ "
" 5 "	70 "	7 "
Weight of flock	321½ "	19 "

During four weeks ending March 12, 20 pounds of fish and 338 lbs. of hay were fed flock No. 2. At this date—

Sheep No. 6 weighed	55½ lbs., a gain of	3½ lbs.
" 7 "	79 lbs., a loss of	2 "
" 8 "	71½ "	1 "
" 9 "	67½ "	½ "
" 10 "	63 "	1½ "
Weight of flock	336½ "	1½ "

During the above four weeks the *corn-fed flock*, weighing 340½ pounds, ate 335 pounds of hay and lost 19 pounds in weight. The flock eating fish, weighing 338 pounds, ate 338 pounds hay and lost 1½ pounds.

During four weeks ending April 9, 19 pounds corn were fed flock No. 1. At this date—

Sheep No. 1 weighed	51 lbs., a gain of	½ lbs.
" 2 "	76½ "	1 "
" 3 "	75½ "	6½ "
" 4 "	64½ "	8 "
" 5 "	78½ "	8½ "
Weight of flock	346 "	24½ "

During four weeks ending April 9, 19 pounds of fish were fed flock No. 2. At this date—

Sheep No. 6 weighed	62 lbs., a gain of	6½ lbs.
" 7 "	84 "	5 "
" 8 "	75 "	3½ "
" 9 "	71 "	3½ "
" 10 "	65 "	2 "
Weight of flock	357 "	20½ "

During four weeks ending May 7, 15 pounds of corn were fed flock No. 1. At this date—

Sheep No. 1 weighed	55 lbs.,	a gain of	4 lbs.
" 2 "	79	"	$2\frac{1}{2}$ "
" 3 "	80	"	$4\frac{1}{2}$ "
" 4 "	65	"	$\frac{1}{2}$ "
" 5 "	82	"	$3\frac{1}{2}$ "
Weight of flock	361	"	15 "

During four weeks ending May 7, 15 pounds of fish were fed flock No. 2. At this date—

Sheep No. 6 weighed	62 lbs.,	a gain of	0 lbs.
" 7 "	87	"	3 "
" 8 "	75	"	0 "
" 9 "	73	"	2 "
" 10 "	67	"	2 "
Weight of flock	364	"	7 "

Recapitulation.—During the sixteen weeks of the experiment—

Sheep No. 1 gained	9 lbs.
" 2 "	2 "
" 3 "	13 "
" 4 "	10 "
" 5 "	14 "
Flock No. 1 gained	48 "

Fed with corn—weighing, January 15, 313 pounds. Gained 48 pounds, or $15\frac{1}{3}$ per cent.

Sheep No. 6 gained	13 lbs.
" 7 "	13 "
" 8 "	$6\frac{1}{2}$ "
" 9 "	6 "
" 10 "	6 "
Flock No. 2 gained	$47\frac{1}{2}$ "

On fish—weighing, January 15, $316\frac{1}{2}$ pounds. Gained $47\frac{1}{2}$ pounds, or $15\frac{1}{126}$ per cent.

That is to say, the corn-fed flock gained 48 pounds, and the fish-fed flock $47\frac{1}{2}$ pounds during the sixteen weeks of the experiment.

Professor Farrington has courteously favored me with some further, but as yet unpublished, details of his experiments. The fish scrap from herring was unground and some of the fragments were rather coarse. It was hard to get the sheep to eat much of the fish, though they gradually learned to like it better. This accounts for the very small quantity consumed.

A second trial similar to the above was made the succeeding winter, and with like results, except that the sheep ate rather more of the fish. In one case a flock of four consumed 28 pounds in four weeks, which is equivalent to 4 ounces per head per day, while in the above series they averaged only about 2 ounces per head per day. The meal was regulated by the amount of fish consumed. The quantities of both were thus extremely small. It is to be noted, however, that the sheep had "all the good hay they would eat." The fish was distasteful, and they took very little. If they had received a fixed quantity of staw, cornstalks, or poor hay, instead of good hay *ad libitum*, they could doubtless have been got to eat more fish, and would probably have learned to like it.

Mr. Wilder, of Pembroke, whose statements were quoted above, and who furnished the scrap for Professor Farrington's experiments, "keeps about one hundred sheep * * * on threshed straw with one-half pound per day to each sheep of dried fish pomace * *, for which the sheep are more eager than they are for grain * * *, and they come out in the spring much better than when fed on good English hay with corn."

Professor Farrington agrees with me in the opinion, indeed the experience of farmers who have fed fish successfully leaves room for no other, and the European experimenters quoted below say the same thing, that sheep, swine, and probably neat cattle, can be taught to eat fish, and when once wonted to it will take it with excellent relish.

A dry, well-prepared, and finely-ground product, such as may be made by the Goodale or other processes, would doubtless keep better, be more free from offensive odor and taste, and worth much more for feeding than the ordinary scrap.

European experiments on digestion and nutritive value of fish, meat-scrap, etc.

324. The need and value of nitrogenous foods for food mixtures, explained and attested by science and confirmed by experience in Europe, has led to diligent seeking, careful trial, and rational use of available foods from every source. Of late a great deal of attention has been paid to animal products. The flesh meal left from the preparation of "Liebig's Meat Extract" in South America, the dried blood of slaughter-houses, and fish guano have all been tested and found extremely valuable.

The scope of the present article precludes details of the experiments on the digestibility and nutritive value of animal foods for stock; I therefore reserve them for a future occasion, and note briefly here some of the main results.

The following are among the experiments of this sort reported in the years 1876 and 1877. The original accounts are in "Die landwirthschaftlichen Versuchs-Stationen," the "Journal für Landwirthschaft," and the "Landwirthschaftliche Jahrbücher" for those years:

Experimenters.	Experiment stations.	Animals.	Food.
I. Wolff, and associates	Hohenheim	Swine	South American flesh meal and potatoes.
II. Wolff, and associates	....do	...do	Flesh meal, pea meal, potatoes, and starch.
III. Wildt	Kuschen	Sheep	Blood meal, flesh meal, and barley straw.
IV. Wildt	....do	Swine	Blood meal, pease, and potatoes.
V. Weiske, and associates	Proskau	Sheep	Fish guano.
VI. Kellner, and associates	Hohenheim	...do	Fish guano, Lucern hay, and oatmeal.

The general plan of each of these experiments was to feed the animals during different periods of two or three weeks each with different foods and mixtures, and to note, by careful weighings and analyses of foods and excrements, the amounts digested. The most prominent of the questions has been the comparative digestibility and nutritive value of vegetable and animal albuminoids. As a general result the albuminoids and fats of meat, blood, and fish are found to be as digestible or more so than those of the most concentrated vegetable foods.

In I, Wolff found swine to digest from albuminoids 92 parts and fats 97 parts out of every 100 parts of each in the flesh meal, and concludes that flesh meal is an easily digested and intensely nutritious food.

In II, Wolff found that the albuminoids in pease and fleshmeal had essentially the same effect.

From III, Wildt found some difficulty in getting sheep to eat the blood and flesh. He says that potatoes and roots will help to make the flesh and blood palatable, and thinks that these may be used with profit to supply albuminoids to herbivorous animals.

From IV, Wildt concludes that animal albuminoids may serve just as well as vegetable for supplying nitrogen to foods poor in albuminoids.

From V and VI, Weiske and Kellner conclude that fish guano, like meat and blood, may be fed with profit to herbivorous animals. In Kellner's experiment two two-year old wethers were fed during the first period with Lucern hay. During the second part the hay was replaced by

oatmeal, and during the third Norwegian fish guano was added to the ration of the second period. At first the animals did not like the fish, but on mixing it well with the oatmeal they accepted it more readily. At the close of the experiment they had got to liking the guano so much as to eat it greedily with no admixture of other foods. They digested on average of two experiments 90 per cent. of the albuminoids and 76 per cent. of the fat of the guano. Concerning the nitrogenous matter of the bone, Kellner made the same observation as has been previously noted, namely, that it was quite rapidly digestible. It is particularly worthy of remark that the Norwegian fish guano which was used in this experiment had 9.44 per cent. nitrogen and no less than 15.77 per cent. phosphoric acid, and only 2.11 per cent. fat. That is, it had more bone than our fish guano. This is because it is made not of the whole fish, but of the refuse heads, entrails, and bones. The most of the fat had been removed by the steaming process used in preparation of the guano.

General conclusions concerning fish as food for domestic animals.

325. On the whole, then, these experiments bear unanimous and convincing testimony in favor of the easy digestibility and high nutritive value of animal foods in general and of fish guano in particular when fed to sheep and swine.

How far they could be made profitable for other herbivorous animals than sheep has not yet been tested. In the nature of the case there is no reason why they should not be as nutritious for neat cattle as for sheep. As Voit has justly observed, all mammals are at one period of their lives, when living upon milk, carnivorous. Late investigations have shown very clearly that even plants are positively nourished by animal foods. The very interesting experiments of Mr. Francis Darwin with the round-leaved sundew demonstrate conclusively that plants may thrive on a meat diet.

In short, we have every reason, from practical experience, from actual experiment, and from what we know of the nature of the case, to believe that the immense amount of animal waste produced in this country from our slaughter-houses, and especially from our fisheries, can be utilized with the greatest ease and profit to supply the most pressing need of a most important part of our agriculture, nitrogenous food for stock.

We have seen that farmers in New England and in Europe have found fish good for their stock, that occasionally one like Mr. Wilder has hit upon a rational way of using it to piece out and improve the poorer products of their farms, and that patient research has explained why it is useful and how it may be made more so. This is one of the countless cases where practical men have worked their way in the dark by the tortuous path of experience to the same results to which scientific investigation leads. But here as ever the results when found need the light of science to explain the facts and make it possible to apply them most profitably.

53. SUMMARY.

Fish as manure.

326. The following is a brief recapitulation of the main points urged in this article:

1. The value of fish as manure is due mainly to its nitrogen and phosphoric acid.

2. Taking into account composition, quality, and price, fish manures furnish these ingredients more cheaply than any other class of fertilizers in the market except Peruvian guanos.

3. The crops most benefited by fish manures are those which need considerable nitrogen and phosphoric acid, but are not especially helped by mineral manures alone. Such are grass, grain, and corn. The same is generally true of potatoes and garden vegetables, and sometimes of roots. Leguminous crops, like clover, beans, and pease, are more benefited by mineral manures, and get little good from the nitrogen of the fish.

4. Fish manures are quick and stimulating in their action. Their force is soon spent and they often leave the soil in worse condition than before they were applied. This is, however, no argument against their value. The remedy for such cases is to apply other materials, as ashes, lime, potash salts, dung, muck, etc., with them.

5. The proper soils for fish manures are those which are deficient in nitrogen and phosphoric acid, and in which the stimulating effect of the decomposition of fish may render other materials available for plant food. Soils that have been treated repeatedly with fish, guano, phosphates, and bone are often overstocked with these ingredients and deficient in potash. Many soils are originally poor in potash. To apply fish on such soils and omit the lacking elements is to lose both fertilizer and crop. The deficiencies of a given soil are best told by actual trial, with different manures and crops.

6. The general usefulness of fish manures will be increased by adding to them phosphoric acid, in the form of bone or superphosphates, and potash in German potash salts. Fine steamed bone, that can be bought for \$32 to \$45 per ton, or "plain" superphosphates, made from South Carolina or Canada phosphates, and sold at \$30 to \$32 per ton, are economical sources of phosphoric acid. The "50 per cent. muriate," sold at about \$40 per ton, is one of the cheapest grades of potash salts. Of the "ammoniated" superphosphates, a very few of the best brands are sold at cheaper rates than it would cost the farmer to make them. But instead of buying medium and inferior articles, farmers will do better to buy the materials and mix them at home.

7. The best form of fish manures is the dry-ground fish guano freed from oil. The water and oil add weight and bulk without increasing value. The coarse fish-scrap cannot be thoroughly spread, is not easily diffused by the water in the soil, is reached by few roots, and becomes slowly

available to the roots that find it. But the fine dry fish is easily spread, is diffused by rain, is thus made accessible to a large number of roots, and can be absorbed by them when they reach it.

8. The ingredients of fish may be made more available for plant-food and their value for manure increased by—

a. Fermentation with urine.

b. Composting with muck, earth, ashes, lime, bone, potash salts, and farm-refuse of all sorts.

c. Feeding to stock, thus putting it through a process similar to that by which Peruvian guano has been formed. In this way it can be used to enrich the manure made on the farm, and thus made one of the best aids to successful farming.

Fish as food for stock.

9. The chief defect of our fodder materials as a whole is their lack of nitrogen. From poor manuring our crops are not only small in quantity, but poor in quality. They lack nitrogen. This is true of our forage crops in general, and of poor hay, straw, and corn-stalks in particular. What our farming most wants, to make stock-feeding profitable, manure plenty and rich, and crops large and nutritious, is nitrogen.

10. One of the cheapest, most useful, and best forms in which this can be furnished is in fish products. These have been found very profitable for feeding in Europe. Our fish guanos are better than the European for this purpose, because they have more flesh and less bone.

The loss to our agriculture from waste of fish.—The evil.

11. Millions of pounds of fish not fit for human food are allowed every year to escape from nets into the sea, which, if saved and rightly utilized, would be worth untold sums for fertilizers and feeding materials.

12. Of the fish saved and used for fertilizers, a large portion is ill-prepared.

13. A large part of that which is well made is exported to Europe, where its value is better understood, and its use is more rational and profitable.

14. A great deal of the fish manure that gets into farmers' hands, be it well or ill prepared, is wasted by wrong application, and by use where it does not fit the needs of crop and soil.

15. A still greater loss comes from the neglect to use fish as food for domestic animals.

16. The total loss to our agriculture from all these sources is not capable of accurate computation, but amounts certainly to hundreds of thousands, and doubtless millions of dollars annually.

The remedy.

17. As the main source of the evil is ignorance, the chief reliance for cure must be in better understanding of the facts and the ways to improve.

18. The needed knowledge can be gained from two sources. The results of European experience and experimenting will be one; experiments and investigations of our own products in our own laboratories, fields, and stables, another. The knowledge once obtained and set forth in detailed reports will, in the natural course of things, be condensed and diffused through the agricultural press, and applied by manufacturers and farmers, to the great benefit of all.

19. The compilation of results of foreign work can be made by reference to the numerous German, French, and English scientific and agricultural journals through which the original memoirs are scattered.

20. The investigations would be properly divided into those on fish as manure and those on fish as food for animals.

21. The experiments on fish as manures would probably be made—

1. In the laboratory, and consist of: *a*, analyses of fish products; *b*, investigations on their changes in composition and action in the soil.
2. In the field, and consist of rationally planned and carefully conducted trials with different fertilizing materials, including fish manures, on different soils and with different crops, in order to obtain specific answers to specific questions whose solution is important.

22. The experiments on fish as food for stock should be made—

1. On farms, by feeding out fish with ordinary foods in simple ways, as was done by Professor Farrington at the Maine State College.
2. In stables fitted up for trials with simultaneous laboratory work, on the plan of the European experiments, above described. The object of these trials would be to determine the digestibility and nutritive effect of the materials employed.

The urgent need of popular instruction.

327. Here is a case where men with the best intentions in the world, fishermen, manufacturers, and farmers, are suffering the waste of thousands, and even millions of dollars' worth of material, bitterly needed to supply the wants of worn-out soils and make bread and meat for hungry men. The first step toward stopping this must be the getting of information. In Europe, governments, agricultural schools, societies, and experiment stations would, in fact do, grapple the questions, and with the best talent, aided by the best appliances that ingenuity, enthusiasm, and money can procure, work at them until they are solved. But here, we shall not get the needed knowledge until some educational institution, experiment station, or other agency, takes hold of the work with a will and put it through.

APPENDIX A.

CIRCULAR RELATING TO "STATISTICS OF THE MENHADEN FISHERY."

OFFICE UNITED STATES COMMISSIONER OF FISH AND FISHERIES,
Washington, D. C.

Among the most important of the marine fishes of the coast of the United States is the species known as the Mossbunker about Long Island and New Jersey; bony-fish and menhaden on the south coast of New England; and pogy (not porgy) on the eastern coast; elsewhere as the bug-fish, yellow-tail, &c., and by naturalists as *Brevoortia menhaden.* Generally considered unfit for food, it is principally captured for bait or for its oil, and for the scrap or refuse left after the oil is squeezed out by means of the hydraulic press.

It is considered very desirable to obtain as full an account as possible of the habits, migrations, &c., of this fish, as well as complete statistics of its capture and uses. I therefore beg leave to call attention to the following queries, and to request answers to as many as practicable. It is not necessary to repeat the queries, a reference to the number affixed to the question being sufficient. Replies should be made on foolscap paper, if equally convenient, and written on one side only of the page.

The information thus obtained will be embodied in a report to Congress, in which full credit will be given to all contributors.

SPENCER F. BAIRD,
Commissioner.

SMITHSONIAN INSTITUTION, *December* 20, 1873.

A.—NAME.

1. By what name is this species known in your vicinity?

B.—ABUNDANCE.

2. How does this fish compare in abundance with others found in your vicinity?

3. Has it diminished or increased in numbers within the last ten years?

4. What was the number of barrels taken in 1873 by any or all establishments in your vicinity—naming them, if possible? Give the same facts for any other year.

5. Does the extensive capture affect their abundance?

C.—MIGRATION AND MOVEMENTS.

6. When are the fish first seen or known to come near the coast, and when does the main body arrive; are the first the largest; are there more schools or runs than one coming in, and at what intervals?

7. Do the schools of fish swim high or low, and is their arrival known otherwise than by their capture—that is, do they make a ripple on the water; do they attract birds, &c.?

8. By what route do these fish come in to the coast, and what the subsequent movements?

9. Is the appearance of the fish on the coast regular and certain, or do they ever fail for one or more seasons at a time, and then return in greater abundance; if so, to what cause is this assigned?

10. Does the use of nets, seines, &c., used in catching them, tend to scare them farther from the shore, their usual feeding grounds?

11. What is the relation of their movements to the ebb and flow of the tide?

12. What are the favorite localities of these fish?

13. What depth of water is preferred by these fish, and how low do they swim?

14. Does the temperature of the water appear to affect them?

15. Do these fish come on to the breeding grounds before they are mature, and do you find the one or two year old fish with the oldest?

16. Are young fish ever seen on the coast; if so, when, and of what size?

17. When do the fish leave the coast, and is this done by degrees or in a body?

18. By what route do they leave the coast?

19. Where do they spend the winter season?

D.—Food.

20. What is the nature of their food?

E.—Reproduction.

21. Where do these fish spawn and when?

22. Can you give any account of the process, whether males and females go in pairs, or one female and two males; whether the sexes are mixed indiscriminately, etc.?

23. Is the water whitened or colored by the milt of the males?

24. What temperature of water is most favorable for spawning?

25. At what depth of water are the eggs laid, if on or near the bottom?

26. Do the eggs, when spawned, sink to the bottom and become attached to stones, grass, &c., or do they float in the water until hatched?

27. When are the eggs hatched, and in what period of time after being laid?

28. Are the young of this fish found in abundance and in what localities?

29. Is the spawn ever found to run from the fish when handled after capture?

F.—ENEMIES AND FATALITIES.

30. What enemies interfere with or destroy the spawn or the young fish; do the parent fish devour them?

31. Are crabs, worms, lampreys, or other living animals found attached to the outside, or on the gills, or in the mouth, especially the roof of the mouth?

32. To what extent do they suffer from the attacks of other fish or other animals—as sharks, blue-fish, porpoises, &c.?

33. Has any epidemic or other disease ever been noticed among them, such as to cause their sickness or death in greater or less numbers?

G.—CAPTURE.

34. What kind of nets are used in the capture of this fish?

35. What are the dimensions (length and depth) of the nets used?

36. What kind of vessels are employed and what is the tonnage?

37. What is the number of men required for the management of vessel and nets?

38. What part of each day is employed in fishing?

39. Are the fish taken more on one tide than another?

40. Does the wind have an effect on them?

41. What is the number of vessels employed in your vicinity and what is the aggregate number of their crews?

H.—ECONOMICAL VALUE AND APPLICATION.

42. What disposition is made of the fish caught; whether used on the spot or sent elsewhere; and, if so, where?

43. What oil factories are there in your neighborhood and by whom owned?

44. What is the gross quantity of oil manufactured in a year at each factory?

45. What is the productive capacity for oil-manufacture of each factory in each year?

46. What is the description and cost of machinery used in trying-out oil in each factory?

47. What prices were paid per barrel for fish in 1873 and what in previous years?

48. What is the average quantity of fish required to produce a gallon of oil?

49. What quantity of oil can be obtained from one ton of scrap?

50. What is the least amount of oil per barrel of fish and when is it least?

51. What is the greatest amount of oil per barrel and when is it greatest?

52. Do the Northern fish yield more than Southern?

53. What is the history of the oil-manufacture on this coast?

54. Where is the principal market for the oil?
55. Where is the principal market for the scrap?
56. What use is made of the oil?
57. What is the range of prices paid for the oil in 1873 and what in previous years?
58. Is it probable that the catch of fish (menhaden), however practiced, tends to diminish them?
59. Name of correspondent.
60. Residence.
61. Date of communication.

APPENDIX B.

LIST OF CORRESPONDENTS FROM WHOM CONTRIBUTIONS HAVE BEEN RECEIVED.

Contributions have been received from the following persons:

J. Matthew Jones, esq., F. L. S., Halifax, N. S.
William H. Sargent, collector of customs, Castine, Me.
Robert A. Friend, oil manufacturer, Brooklin, Me.
J. C. Condon, oil manufacturer, Belfast, Me.
Charles G. Atkins, Bucksport, Me.
Marshall Davis, deputy collector of customs, Belfast, Me.
John Grant, keeper of Matinicus Rock Light Station, Me.
Mrs. B. Humphrey, keeper of Manhegin Island Light-House, Me.
Alden H. Jordan, keeper of Baker's Island Light-House, Me.
William S. Sartell, keeper of Pemaquid Light Station, Me.
James A. Hall, collector of customs, Waldoborough, Me.
Benjamin F. Brightman, Round Pond, Me.
Luther Maddocks, oil manufacturer, Boothbay, Me., secretary Maine Menhaden Oil and Guano Association.
G. B. Kenniston, oil manufacturer, Boothbay, Me.
Thomas Day, keeper of Seguin Light, Parker's Head, Me.
J. Washburne, jr., collector of customs, Portland, Me.
Hon. S. L. Goodale, Saco, Me.
Washington Oliver, keeper of Pond Island Light, Me.
Chandler Martin, keeper of Whale's Back Light, N. H.
Judson Tarr & Co., oil manufacturers, Rockport, Mass.
F. J. Babson, collector of customs, Gloucester, Mass.
Cyrus Story, Gloucester, Mass.
Capt. Robert H. Hurlbut, Gloucester, Mass.
Unknown contributor, Gloucester, Mass.
Simeon Dodge, collector of customs, Marblehead, Mass.
Eben B. Phillips, oil dealer, Boston, Mass.
W. Stowe, American Net and Twine Company, Boston, Mass.

William Atwood, keeper of Duxbury Pier Light-House, Plymouth, Mass.
Thomas Loring, collector of customs, Plymouth, Mass.
Heman S. Dill, keeper of Billingsgate Island Light-House, Wellfleet, Mass.
David F. Loring, keeper Highland Light-Station, North Truro, Mass.
Capt. N. E. Atwood, Provincetown, Mass.
Capt. Josiah Hardy, 2d, keeper of Chatham Light-House, Mass.
Philip Smith, North Eastham, Mass.
William S. Allen, keeper, Great Point Light, Nantucket, Mass.
Reuben C. Kenney, Nantucket, Mass.
T. C. Defriez, collector of customs, Nantucket, Mass.
Alonzo F. Lothrop, keeper of Hyannus Light-House, Mass.
C. B. Marchant, collector of customs, Edgartown, Mass.
Jason Luce & Co., pound fishermen, North Tisbury, Mass.
Capt. J. B. Edwards, Light-House Buoy Station, Wood's Holl, Mass.
E. F. Crowell, Wood's Hole, Mass.
Capt. Thomas Hinckley, jr., Wood's Holl, Mass.
Prof. C. A. Goessmann, Amherst, Mass.
Daniel T. Church, oil manufacturer, Tiverton, R. I.
Joseph Whaley, keeper of Point Judith Light, R. I.
E. T. De Blois, Portsmouth, R. I.
H. O. Ball, New Shoreham, R. I.
Joshua T. Dodge, Block Island, R. I.
Henry W. Clark, keeper of South East Light-House, Block Island, R. I.
Capt. Jared S. Crandall, keeper of Watch Hill Light, R I.
Gallup, Morgan & Co., Groton, Conn.
Capt. John Washington, fisherman, Mystic River, Conn.
Capt. William H. Potter, fisherman, Mystic River, Conn.
Luce Brothers, East Lyme, Conn.
Capt. Leander Wilcox, fisherman, Mystic Bridge, Conn.
Capt. Samuel G. Beebe, keeper of Cornfield Point Light-Vessel, Saybrook, Conn.
Richard E. Ingham, keeper of Saybrook Light-House, Conn.
Prof. J. Hammond Trumbull, Hartford, Conn.
George W. Burke, M. D., deputy collector of customs, Middletown, Conn.
Capt. J. L. Stokes, oil manufacturer, Westbrook, Conn.
George W. Miles, oil manufacturer, Milford, Conn.
E. H. Jenkins, New Haven, Conn.
H. L. Dudley, secretary U. S. Menhaden Oil and Guano Assciation, New Haven, Conn.
F. Lillingston, Stratford, Conn.
B. Lillingston, Stratford Point Light-House, Conn.
W. S. Havens, collector of customs, Sag Harbor, N. Y.
Capt. Joseph D. Parsons, Springs, N. Y.
Capt. B. H. Sisson, United States Coast Survey, Greenport, N. Y.
David F. Vail, oil manufacturer, Riverhead, N. Y.

Hawkins Brothers, oil manufacturers, Jamesport, N. Y.
Seaman Jones, New York City.
W. O. Allison, editor Oil, Paint, and Drug Reporter, New York City.
Jasper Pryer, New York City.
E. G. Blackford, fish dealer, New York City.
J. Norrison Raynor, agent for Sterling & Co., Greenport, N. Y.
Barnet Phillips, New York Times, New York City.
Louis C. d'Homergue, Brooklyn, N. Y.
F. F. Beals, secretary American Sardine Company, New York City and Port Monmouth, N. J.
D. E. Foster, keeper of Cape May Light-House, N. J.
A. G. Wolf, keeper of Absecom Light-House, Atlantic City, N. J.
Capt. John D. Sanders, Leedsville, N. J.
Albert Morris, Somers Point, N. J.
A. A. Owens, Philadelphia, Pa.
Joseph B. Benson, Bombay Hook, Del.
James H. Bell, keeper Mispillion River Light-House, Delaware Bay.
Benjamin Tice, keeper of Maurice River Light-House.
Isaac D. Robbins, keeper of Hog Island Light.
Hance Lawson, collector of customs, Crisfield, Md.
Dr. H. C. Yarrow, U. S. A., Washington, D. C.
J. L. Anderton, Apateague Island, Accomac County, Va.
G. Henry Selden, Kinsale, Westmoreland County, Va.
Henry Richardson, keeper of Cape Henry Light-House, Va.
Charles G. Manning, collector of customs, Edenton, N. C.
A. W. Simpson, jr., assistant keeper Cape Hatteras Light, N. C.
Wallace R. Jennett, Cape Hatteras, N. C.
A. C. Davis, collector of customs, Beaufort, N. C.
William F. Hatsel, keeper of Body's Island Light-House, N. C.
Patrick Conner, keeper of Daufuskie Island, S. C., Range Beacons.
George Gage, collector of customs, Beaufort, S. C.
W. A. Ham, keeper of Range Beacons Light-House, Morris Island, S. C.
H. W. Reed, keeper of Tyler Light, Savannah River, Ga.
J. F. Hall, Brunswick, Ga.
Joseph Shepard, collector of customs, Saint Mary's, Ga.
Francis C. Goode, Arlington Bluffs, Saint John's River, Fla.
Capt. David Kemps, Yellow Bluffs, Saint John's River, Fla.
Dr. Charles Koch, Jacksonville, Fla.
Charles Dougherty, New Smyrna, Fla.
S. H. Wilkinson, keeper of Cat Island Light-House, Miss.
Silas Stearns, Pensacola, Fla.
D. P. Kane, keeper Matagorda Light-House, Tex.

The communications of Messrs. F. J. Babson, E. B. Phillips, Josiah Hardy, David T. Church, W. S. Havens, B. H. Sisson, James H. Bell, A. W. Simpson, jr., A. C. Davis, and David Kemps have been particularly valuable as furnishing data concerning habits and migrations;

those of Judson Tarr & Co., J. C. Condon, R. A. Friend, G. B. Kenniston, G. W. Miles, and Hawkins Brothers in the statistics of manufactures; that of Mr. F. J. Babson in the statistics of the bait fisheries, and that of Mr. F. F. Beals in relation to the sardine manufactures. Thanks are due to Melton & Co., of Jacksonville, Fla., for specimens of fish from the Saint John's River.

APPENDIX C.

BIBLIOGRAPHY OF LITERATURE RELATING TO THE MENHADEN.

BREVOORTIA TYRANNUS (Latrobe) Goode.

Clupea tyrannus, LATROBE, Transactions of the American Philosophical Society, vol. v, 1802, p. 77, plate 1 (four figures).

Brevoortia tyrannus, GOODE, Proceedings of the United States National Museum, 1878, p. 5.

Clupea dura lævi mystax (Hard Head), BELKNAP, History of New Hampshire, 2d ed., 1813, vol. iii, p. 133. (Name only.)

Clupea menhaden, MITCHILL, Transactions of the Literary and Philosophical Society of New York, vol. i, 1815, p. 453, pl. v, fig. 7.

COOK, Geology of the County of Cape May, State of New Jersey, 1857, p. 113.

GÜNTHER, Catalogue of Fishes in the British Museum, vol. vii, 1868, p. 436.

WHITEAVES, Notes on the Marine Fisheries, and particularly on the Oyster Beds of the Gulf of St. Lawrence, in Sixth Annual Report Department of Marine and Fisheries, 1874, p. 195.

Alosa menhaden, RICHARDSON, Fauna Boreali Americana, 1836, p. 229.

STORER, Report on the Icthyology and Herpetology of Massachusetts, 1839, p. 117; Memoirs of the American Academy of Arts and Sciences, new series, ii, 1846, p. 459; Synopsis of the Fishes of North America, 1846, p. 207; Mem. Amer. Acad., new series, vi, 1858, p. 386; History of the Fishes of Massachusetts, 1867, p. 158, pl. xxvi, fig. 4, and (?) in Appleton's New American Cyclopedia.

DEKAY, Zoology of New York, or the New York Fauna, part iv, Fishes, 1842, p. 259, pl. xxi, fig. 60.

AYRES, Enumeration of the Fishes from Brookhaven, Long Island. < Boston Journal of Natural History, vol. iv, 1844, p. 275.

PERLEY, Descriptive Catalogue [in part] of the Fishes of New Brunswick and Nova Scotia in Reports on the Sea and River Fisheries of New Brunswick (2d ed.), 1852, p. 208.

BAIRD, Report to the Secretary of the Smithsonian Institution on Fishes of the New Jersey Coast, as observed in the Summer

of 1854. < Annual Report of the Smithsonian Institution for the year 1854, p. 347, and repaged edition, June, 1855, p. 33; Geology of the County of Cape May, State of New Jersey, 1857, p. 147.

GILL, On the Fishes of New York, in Annual Report of the Smithsonian Institution for the year 1856, p. 266.

COOK, op. cit., l. c.

Alausa menhaden, VALENCIENNES in Cuvier and Valenciennes' Histoire Naturelle des Poissons, vol. xx, 1843, p. 424.

Brevoortia menhaden, GILL, Catalogue of the Fishes of the East Coast of North America, 1861, p. 55; Proceedings of the Academy of Natural Sciences, Philadelphia, 1861, p. 37 (diagnosis of genus); Canadian Naturalist, 1867, p. 260, and in Baird's Report on the Sea Fisheries of the South Coast of New England, 1873, p. 826.

STEINDACHNER, in Sixth Annual Report of the Commissioners of Inland Fisheries (Massachusetts), for the year ending January 1, 1872.

BAIRD, List of Fishes collected at Wood's Hole, in Report on the Sea Fishes of the South Coast of New England, 1873, p. 826, and elsewhere in same report, p. 136.

VERRILL, On the Food and Habits of some of our Marine Fishes, in American Naturalist, v, 1871, p. 398; Lists of Species found in the Stomachs of Fishes, in Baird's report sup. cit., 1873, p. 520.

VERRILL, SMITH and HARGER, Catalogue of the Marine Invertebrate Animals of the Southern Coast of New England, and Adjacent Waters, in Baird's report sup. cit., 1873, p. 578 (lernæan parasite).

WHITEAVES, l. c.

BOARDMAN and ATKINS, The Menhaden and Herring Fisheries of Maine, 1875.

GOODE, Catalogue of the Collection to illustrate the Animal Resources of the United States, 1876, p. 63.

UHLER & LUGGER, List of the Fishes of Maryland, in the Report of the Commissioners of Fisheries of Maryland, 1876 (first edition), p. 156; (second edition), p. 133.

HIND, The Effect of the Fishery Clauses of the Treaty of Washington on the Fisheries and Fishermen of British North America, 1877, p. 73.

YARROW, Notes on the Natural History of Fort Macon, N. C., and Vicinity (No. 3), Fishes, in Proceedings of the Academy of Natural Sciences, Philadelphia, 1877, p. 215.

Alosa sadina, MITCHELL, *op. cit.*, p. 457.

DEKAY, *op. cit.*, p. 263, pl. xl, fig. 129.

Alausa shadina, VALENCIENNES, *op. cit.*, p. 426.

Clupea neglecta, RAFINESQUE, Second Decade of New North American Fishes, in American Monthly Magazine, vol. ii, 1818, p. 206.

Clupanodon aureus, SPIX, Selecta Genera et Species Piscium, Brazil, 1829, p. 52, tab. xxi.

Alosa aurea, VALENCIENNES, *op. cit.*, p. 427.

Clupea aurea, GÜNTHER, *op. cit.*, p. 437.

Clupea Carolinensis, GRONOW, Catalogue of Fish collected and described by Lawrence Theodore Gronow, now in the British Museum (ed. GRAY), 1854, p. 40.

"Fish Guano," HALLIDAY, S. B., in Country Gentleman, vol. vi, p. 250.

S. W. JOHNSON, *Ibid.* vol. viii, p. 43.

COOK, *op. cit.*

"Menhaden Fisheries and their Products, A new source of Commercial Industry." By LOUIS C. D'HOMERGUE, <in The Manufacturer and Builder, vol. iii, p. 114, May, 1876.

"The Fish Oil and Scrap Business," CONNECTICUT, in American Agriculturist, vol. xxxii, 1873, p. 139.

"Fish Scrap or Guano," EDITORIAL, *ibid.* xxxi, 1872, p. 419.

"The Manufacture of Fish Oil and Guano," ANONYMOUS, *ibid.* xxvi, 1867, p. 400 (with wood cut of menhaden).

"A Fish Oil and Guano Factory," EDITORIAL, *ibid.* xxvii, 1868, p. 451 (with wood cuts of factories and fishing scenes).

"Pound fishing for menhaden."

LYMAN, On the Possible Exhaustion of Sea Fisheries, in Sixth Annual Report of the Commissioners of Inland Fisheries (Mass.), 1872, p. 24.

"The Sardine Industry"—

ANONYMOUS in Harpers Weekly, January, 1875, and Scientific American, February 6, 1875 (with wood cuts of fisheries and process of manufacture).

MENHADEN USED AS FOOD—

ANONYMOUS in Topography and History of Wareham, 1815, in collections of the Mass. Hist. Society, iv, second series, 1816, p. 284.

STORER, l. c., GILL. Fishes of New York.

USE OF RAW FISH FOR MANURE—

FIELD, DAVID D., in Statistical Account of the County of Middlesex, in Connecticut, 1819, p. 153.

THOMPSON, BENJAMIN F., in his History of Long Island, 1839, p. 44.

DWIGHT, TIMOTHY, in his Travels in New England, pp. 305, 513.

BOARDMAN, SAMUEL L. and ATKINS, CHARLES G.

The | Menhaden and Herring Fisheries | of Maine | as sources of fertilization | A Report made to the Maine Board of Agriculture | By Samuel L. Boardman, Secretary of the Board | and | Charles G. Atkins, formerly Fish Commissioner of Maine | 8vo., 1875, pp. 67.

PACIFIC GUANO COMPANY.

The | Pacific Guano Company | its History; its Products and Trade; | its Relation to Agriculture | — | Exhausted Guano Islands of the Pacific Ocean; | Howland's Island, Chincha Islands | etc., etc. | — | The Swan Islands | — | The May Beds and Phosphate Rock of South Carolina | Chisolm's Island Phosphate | The Menhaden | Cambridge: | Printed for the Pacific Guano Company | at | The Riverside Press | 1876 | 8vo., pp. 63.

MADDOCKS, L.

The Menhaden fishery of Maine | with statistical and historical details | its | relations to agriculture | and as a | direct source of human food | — | new processes, products, and discoveries | — | Published by the | Association of the Menhaden Oil and Guano Manufacturers of Maine | Press of B. Thurston & Company, Portland, 1878. Prepared by Mr. Luther Maddocks.

THE MENHADEN AS A BAIT FISH—

Professor Spencer F. Baird, Testimony before the Halifax Commission, 1817, Appendix L, pp. 467, 469.

James Bradley, Testimony, Halifax Commission, 1877, Appendix L, p. 5.

Edward Stapleton, *ib.*, p. 11.

Nathaniel E. Atwood, *ib.*, p. 42.

Benjamin Maddocks, *ib.*, p. 138.

Benjamin Ashby, *ib.*, pp. 246–7.

Robert H. Hulbert, *ib.*, p. 296.

Sylvanus Smith, *ib.*, pp. 334, 341, Appendix M, p. 81.

Major David W. Low, *ib.*, pp. 362, 364, 367, 268.

James H. Myrick, *ib.*, p. 428.

Spencer F. Baird, *ib.*, pp. 457, 458, 460.

William Eaton, Appendix M, p. 6.

L. G. Crane, *ib.*, p. 8.

H. E. Willard, Cape Elizabeth, Me., pp. 10, 11.

Enoch G. Willard, *ib.*, pp. 15, 16.

George Trefethen, *ib.*, pp. 17, 18.

John Conley, *ib.*, p. 21.

O. B. Whitten, *ib.*, p. 23.

S. B. Chase, *ib.*, pp. 25, 26.

M. N. Rich, *ib.*, pp. 27, 28.

Noah Swett, *ib.*, pp. 30, 31.

C. C. Pettingell, *ib.*, pp. 33, 34.

William H. Nelson, *ib.*, pp. 35, 36.

A. W. Small, *ib.*, pp. 38–39.

C. E. Smalley, R. C. Kenney, *ib.*, pp. 40, 41.

Elisha Crowell, *ib.*, pp. 42, 43.

Caleb Nickerson, *ib.*, pp. 45, 46.

Horatio Babson, *ib.*, pp. 48, 49.

F. W. Friend, *ib.*, pp. 51, 52.
George W. Plumer, *ib.*, pp. 54, 55.
H. Knowlton, E. A. Horton, *ib.*, pp. 57, 58.
Albion K. Pierce, *ib.*, pp. 60, 61.
George Norwood, *ib.*, pp. 63, 64.
Andrew Leighton, *ib.*, pp. 66, 67.
W. C. Wonson, *ib.*, pp. 68, 69.
George Friend & Co., *ib.*, pp. 71, 72.
Frederick Gerring, *ib.*, pp. 73, 74.
F. G. Wonson, *ib.*, pp. 76, 77.
Charles H. Pew, *ib.*, pp. 78, 79.
Mauris Whelen, *ib.*, p. 82.
Thomas Grady, *ib.*, p. 82.
James G. Tarr, *ib.*, p. 83.
John E. Gorman, *ib.*, p. 84.
Henry Hardy, *ib.*, p. 85.
John E. Saunders, *ib.*, p. 86.
Richard Hannan, *ib.*, p. 86.
James G. McKean, *ib.*, p. 195.
George Crichet, *ib.*, p. 202.
Christopher Carrigan, *ib.*, p. 202.
Martin Ryan, *ib.*, p. 204.
Philip Ryan, *ib.*, p. 204.
Andrew Laurie, *ib.*, p. 205.
Thomas England, *ib.*, p. 205.
Rufus Carrigan, *ib.*, p. 206.
Charles Lowrie, *ib.*, p. 207.
George Laidlaw, *ib.*, p. 209.
Roderick McDonald, *op. cit.*, p. 210.
Daniel McDonald, *ib.*, p. 211.
Dougald McKinnon, *ib.*, p. 212.
James R. McLean, Appendix F, pp. 24, 29.
Wm. S. McNiell, *ib.*, p. 57.
George Mackenzie, *ib.*, p. 132.
James McKay, *ib.*, p. 190.
John Nicholson, *ib.*, p. 205.
John Maguire, *ib.*, p. 214.
James W. Bigelow, *ib.*, p. 222.
Michael Wrayton, *ib.*, p. 231.
James Lord, *ib.*, p. 245.
John F. Taylor, *ib.*, p. 299.
James A. Tory, *ib.*, p. 323.
James Hickson, *ib.*, p. 342.
John McLellan, *ib.*, p. 404.

Knowles, Charles G. F., Third Report of the Department of Marine and Fisheries, 1871, p. 341.

H. W. Johnston, A Special Report on the Distress among the Nova Scotia Fishermen, 1870.

Case of Her Majesty's Government, *op. cit.*, Appendix A, p. 28.

Answer on Behalf of the United States of America to the Case of Her Britannic Majesty's Government, Appendix B, pp. 18, 19.

Reply on Behalf of Her Britannic Majesty's Government to the Answer of the United States of America, Appendix C, pp. 9, 10.

Richard H. Dana, jr., Appendix J, p. 78; Appendix F, p. 67.

APPENDIX D.

EXTRACTS FROM WRITINGS OF ICHTHYOLOGISTS RELATING TO THE MENHADEN.

[From Transactions of the American Philosophical Society, Vol. V, 1802, pp. 77–81.]

A DRAWING AND DESCRIPTION OF THE CLUPEA TYRANNUS AND ONISCUS PRÆGUSTATOR. BY BENJAMIN HENRY LATROBE, F. A. P. S.

The committee, to whom was referred Mr. Latrobe's paper on a species of *Oniscus*, called by the author *Oniscus prægustator*, reports that the same is worthy of publication.

BENJAMIM SMITH BARTON.

FEBRUARY 17, 1800.

PHILADELPHIA, *December* 18*th*, 1799.

To THOMAS P. SMITH,

One of the Secretaries of the American Philosophical Society:

SIR: I beg leave, through your means, to communicate to the American Philosophical Society an account of an insect, whose mode of habitation, at least during some part of his life, has appeared to me one of the most singular, not to say whimsical, that can be conceived.

In the month of March, 1797, illness confined me, for several days, at the house of a friend on York River, in Virginia, during his absence. My inability to move farther than the shore of the river gave me leisure to examine carefully, and in more than an hundred instances, the fact I am going to mention.

Among the fish that, at this early season of the year, resort to the waters of the York River, the alewife, or old-wife, called the bay-alewife (*Clupea nondescripta*), arrives in very considerable shoals, and in some seasons their number is almost incredible. They are fully of the size of a large herring, and are principally distinguished from the herring by a bay or red spot above gill-fin. They are, when caught, from March to May, full-roed and fat, and are at least as good a fish for the table as the herring. In this season, each of the alewives carries in her mouth an insect, about two inches long, hanging with its back downwards and firmly holding itself by its 14 legs to the palate. The fishermen call this insect "the louse." It is with difficulty that it can be separated, and

perhaps never without injury to the jaws of the fish. The fishermen, therefore, consider the insect as essential to the life of the fish, for when it is taken out, and the fish is thrown again into the water, he is incapable of swimming and soon dies. I endeavored in numerous instances to preserve both the insect and the fish from injury, but was always obliged either to destroy the one or to injure the other. I have sometimes succeeded in taking out the insect in a brisk and lively state. As soon as he was set free from my grasp, he immediately scrambled nimbly back into the mouth of the fish and resumed his position. In every instance he was disgustingly corpulent and unpleasant to handle, and it seemed, whether he have obtained his post by force or by favor, whether he be a mere traveler or a constant resident, or what else may be his business where he is found, he certainly has a fat place of it, and fares sumptuously every day.

The drawings annexed to this account were made from the live insect, and from the fish out of whose mouth he was taken. I had no books to refer to then; but examining the Systema Naturæ of Linnæus, I was surprised to find so exact a description of the insect as follows (see Salvii Editio, Holmiæ, 1763, 1060, also Trattner's Vienna edition, same page):

"Insect, apt. Oniscus, Pedes XIV.
Antennæ setaceæ.
Corpus ovale.

"O. physodes, abdomine subtus nudo caudâ, ovatâ; habitat in pelago; corpus præter caput, et caudam ultimatum, ex septem segmentis trunci, et quinque caudæ. Antennæ utrinque duo, breves. Caudæ folium terminale omino ovatum; ad latera utrinque subtus auctum duobus peteolis diphyllis, foliolis lanceolatis, obtusis, caudâ brevioribus. Caudæ articuli subtus obtecti numerosis vesiculis longitudine caudæ."

From the particularity with which the *Oniscus physodes* is described by Linnæus, it is evident that he had the insect before him, or a description by an attentive observer. It appears also from the "habitat in pelago," that the *O. physodes*, if this be the insect, is found detached from his conductor. There are a few points in which the *O. physodes* differs from my insect. I did not observe the antennæ, perhaps for want of sufficient attention, or of a microscope. The peteoli of the tail were not, to appearance, two-leaved, and I am certain that the segments of the tail, and the tail itself, were without the vesiculi longitudine caudæ.

There are many circumstances, to ascertain which is essential to the natural history of this insect. The fish whose mouth he inhabits comes, about the same time with the shad, into the rivers of Virginia from the ocean, and continues to travel upward from the beginning of March to the middle of May; as long as they are caught upon their passage up the river, they are found fat and full of roe. Every fish which I saw had the *Oniscus* in his mouth, and I was assured, not only by the more ignorant fishermen, but by a very intelligent man who came down now

and then to divert himself with fishing, that, in forty years' observation, he had never seen a bay-alewife without the louse. The shad begin to return from the fresh water lean and shotten about the end of May and beginning of June, and continue descending during the remaining summer months. No one attempts then to catch them, for they are unfit for the table. Whether the bay-alewife returns with the shad, I could not learn, but it is certain that after June it is not thought worth the trouble to catch them. No one could tell me positively whether the *Oniscus* still continues with them, but it was the opinion of my informant, that, like every other parasite, he deserts his protector in his reduced state, for he could not recollect that he had ever seen him in the mouth of those accidentally caught in the seine in July or August.

I consider, therefore, the natural history of the *Oniscus* which I now communicate as very imperfect; and it were to be wished that some lover of natural science would follow up the inquiry, by endeavoring to ascertain whether he continue with, or quit the fish before his return to the ocean, and also whether he be the *Oniscus physodes* of Linnæus, qui habitat in pelago.

Should he be an insect hitherto undescribed, I think he might be very aptly named, *Oniscus prægustator.*

The bay-alewife is not accurately described in any ichthyological work which I have seen; nor can I from my drawings, which were made with a very weak hand, venture a description. From his having a regular prægustator, I would suggest that he ought to be named *Clupea tyrannus.*

The *Oniscus* resembles the minion of a tyrant in other respects, for he is not without those who suck him. Many of those which I caught had two or three leeches on their bodies, adhering so closely that their removal cost them their heads. Most of the marine *Onisci* appear to be troublesome to some one or other fish. The *Oniscus ceti* is well known as the plague of whales, and many of the rest are mentioned in Linnæus and Gmelin as pestes piscium.

BENJA. HENRY LATROBE, *F. A. P. S.*

P. S.—A gentleman well skilled in entomology informs me that he believes that in Block's History of Fishes, a work not to be had in Philadelphia, this *Oniscus* is mentioned. But, from a late examination of Gmelin and Fabricius, I am convinced that the *Oniscus prægustator* is a species not hitherto accurately described. Gmelin had probably seen the Linnæan insect, having changed the antennae utrinque duo to antennis quaternis, and left out most of the long description given by Linnæus. Neither he, Linnæus, nor Fabricius mentions the circumstance of habitation in the mouth of the fish, and the industrious and copious Fabricius, who having changed the names of the genera, calls him *Cymothoa physodes*, copies the description of Gmelin, excepting the mention of the 4 antennae, which in his arrangement form a character of the genus.

[From "The Fishes of New York, described and arranged," by Samuel L. Mitchill, in Transactions of the Literary and Philosophical Society of New York, 1815, p. 453.]

BONY-FISH, HARD-HEADS, OR MARSHBANKERS, OF NEW YORK. (*Clupea menhaden.*)

About fourteen inches long, frequent the New York waters in prodigious numbers. From the high banks of Montock, I have seen acres of them purpling the water of the Atlantic Ocean. The waters of Long Island Sound and its bay are often alive with shoals of them. They are eatable; but as they are too abundant for consumption as food, and as there are multitudes of preferable fish, menhaden are often left to putrefy on the shore or are removed to the fields for manure.

The history of this fish has been written by Mr. B. H. Latrobe, and published with a figure, in the Philosophical Transactions of Philadelphia, Vol. v. And the manner of converting him to an ingredient for fertilizing land has been explained by Ezra L'Hommedieu, esq., in the Agricultural Transactions of New York, Vol. I., p. 65. The aborigines called him menhaden. The whalemen say he is the favorite food of the great bone-whale or Balæna mysticetus. This creature, opening its mouth amidst a shoal of menhaden, receives into its cavity the amount of some hogsheads of menhaden at a gulp. These pass, one by one, head foremost down his narrow gullet; and eye-witnesses have assured me that on cutting up whales after death, great quantities of menhaden had been discovered thus regularly disposed in the stomach and intestines.

Gill-cover very large. One blackish spot on the neck near it. Head and back greenish-brown, with a few marks of brighter green on the head. Belly and sides considerably iridescent. Back arched, rounded, and thick; tail forked; belly serrated; mouth and tongue toothless and smooth; gills rising from the back of the tongue on both sides of the wide throat.

Rays, Br. 7, P. 15, V. 7, D. 19, A. 19, C. 27.

[From "The Fishes of New York described and arranged," by Samuel L. Mitchill, in Transactions of the Literary and Philosophical Society of New York, 1815, p. 457.]

NEW YORK SHADINE (*Clupea sadina*).

An elegant species, with a small smutty spot behind the gill-cover, but with neither spots nor stripes on its back or sides; mouth wide and toothless; tongue small; back delicately variegated with green and blue; lateral line straight; sides silvery white, considerably above that line, and below it quite to the belly; the white reflects vividly green, red, and other splendid hues; head rather elongated; lower jaw projecting; scales very easily deciduous; form neat, taper, and slender; gills rise into the throat on each side of the root of the tongue; eyes pale and large; tail deeply forked; on account of the even connection of the false ribs, the belly is not at all serrated, but quite smooth; a semi-transparent space in front of the eyes from side to side.

Rays, Br. 7, P. 16, V. 9, D. 18, A. 15, C. 19.

[From Storer's "History of the Fishes of Massachusetts," 1867, p. 158.]

ALOSA MENHADEN, Storer. The Menhaden.

(Plate XXVI, Fig. 4.)

Clupea menhaden, Bony-fish, Hard-heads, or Marsh-bankers of New York, MITCH., Trans. Lit. and Phil. Soc. of New York, 1, p. 453, pl. 5, fig. 7.
Alosa menhaden, Menhaden, Hard-head, STORER, Report, p. 117.
Alosa menhaden, Moss-bonker, DEKAY, Report, p. 259, pl. 21, fig. 60.
Alosa menhaden, AYERS, Bost. Jour. Nat. Hist., iv, p. 275; STORER, Mem. Amer. Acad., new series, 11, p. 459.
Alosa menhaden, STORER, Synopsis, p. 207.
L'Alose menhaden, CUV. & VAL., Hist. Nat. des Pois., xx, p. 424.

Color.—Upper part of body of a greenish-brown, darker upon the top of the head and at the snout; upper part of the sides in the living fish roseous and mottled with indistinct bluish oscillations, which disappear in death; abdomen silvery; gill-covers cupreous, with a rosy tint; space in front of the eyes translucent; a black spot, more or less distinct, upon the shoulders; whole surface of the fish iridescent.

Description.—Body elongated, compressed; its depth across, at the base of the pectorals, less than one-fifth the length of the fish; length of the head more than one-third the length of the fish; gill-covers very large; opercula, with numerous deeply marked striæ, which commence just beneath a large green blotch, situated some distance back of the eye and on a line with it, and pass obliquely backward and downward to its lower edge; subopercula and interopercula smooth; preopercula presenting an arborescent appearance of vessels upon their surface; eyes circular, moderate in size, furnished with a nictitating membrane; gape of mouth very large; lower jaw shorter than the upper; the middle of the upper jaw deeply emarginate; back slightly arched in front of the dorsal fin.

The dorsal fin commences upon the anterior half of the body; it is nearly as long again as high, and is emarginated above; at its base is a membranous prolongation or sheath, by which it is almost entirely covered when unexpanded. The first three rays of this fin are simple; the first articulated rays are higher than the remainder, the most posterior higher than the eight or nine preceding.

The pectorals are situated just beneath the posterior inferior angle of the operculum; the first three rays are the longest; the first ray is simple. Outside of this fin is an axillary plate more than two-thirds the length of the fin; a broad scaly shield at the base of the pectorals covers a portion of the inferior edge.

The ventrals are very small and fan-shaped, their rays are multifid; on each side of these fins is an axillary plate.

The anal fin is shorter than the dorsal, low and slightly emarginated above; its anterior rays are highest; the first ray is simple; it is sheathed at its base like the dorsal.

The caudal fin is deeply forked; the depth of the fin at its extremities, when expanded, is equal to the height of the outer rays.

The fin rays are as follows: D. 19; P. 15, 16, or 17; V. 6; A. 20, 21, or 22; C. $20\frac{4}{4}$.

Length, eight to fourteen inches.

[From Dekay's "Zoology of New York," Part IV., Fishes, 1842, p. 259.]

THE MOSSBONKER. *Alosa menhaden.*

(Plate XXI, Fig. 60.)

Bony-fish or Mossbonker. *Clupea menhaden.*
MITCHILL, Report in part, &c., p. 21.
Hard-head or Marsbankers. *C. menhaden.*
Id. Trans. Lit. and Phil. Soc., vol. 1, p. 453.
The Menhaden, Hard-head. *Alosa menhaden.*
STORER, Massachusetts, Report, p. 117.

Characteristics.—Silvery; no stripes; a humeral spot. A double accessory ray to the ventrals. Abdomen serrated behind the ventrals. Length 10–14 inches.

Description.—Body much compressed; its height to its length as one to four nearly. Abdomen cultrate, with a fissure along its edge, indistinctly serrated before the ventrals, sharply serrate behind. Scales large, elliptical, distinctly and evenly ciliate on the free margins; on the back smaller and more crowded; on the nape the scales have longer unequal ciliæ. No appearance of a lateral line. Head large, compressed, one-third of the total length; the opercles with curved and radiating striæ. Mouth large, the upper jaw emarginate on the side. The gill membrane on one side folds over its opposite, with five slender cylindrical, and three larger and flat rays. Branchial arches four, with a small rudimentary one in front, all angular, and with a long minutely fringed filament. Eyes nearly covered by a nictitating membrane. Tongue soft, white, minutely punctate with black. The dorsal fin long, emarginate; the first three rays simple, articulated; the anterior being very short, the remainder branched; first branchial ray highest, the last higher than the four preceding. This fin is concave on its margin, and is placed in a sheath. Pectorals long and pointed on a line with the margin of the opercles; the first ray simple; the accessory plate large and as long as the fifth ray. Ventrals feeble, short, fan-shaped, lying under the anterior portion of the dorsal, with double accessory plates. Anal long and low, the two first rays simple, the first shortest; the last ray longer than the fourteen preceding. Scales covering the base of the rays, so as to form a sort of sheath. Caudal forked, much branched, and with numerous accessory rays. Scales extending high

up on the fin, and very minute ones distributed almost to the tip. Abdomen covered internally with a black pigment. Intestines long and convoluted; cæca numerous, attached to a stout muscular stomach, lined with a white rugose membrane, covered with numerous papillæ. Air-bladder simple.

Color.—Summit of the head and back greenish; silvery on the sides. In the plates, more of a yellow hue is given to this fish than belongs to him. A dark brown spot on the shoulders, behind the opercles. Irides yellow. A space anterior to the eyes so translucent as to permit opaque objects to be seen through on the other side.

Length 8.0–14.0.

Fin-rays, D. 20; P. 16; V. 6; A. 22; C. $20\frac{4}{4}$.

This fish is known under the various names of bony-fish, hard-head, mossbonkers (or, as it is pronounced by our Dutch inhabitants, morsebonkers), panhagen, and menhaden; the last being the name given by the Manhattans, and panhagen (pronounced panhangen) the Narragansett epithet. At the east end of the island, they are called skippangs, or bunkers. Although seldom eaten, as it is dry, without flavor, and full of bones, yet it is one of the most valuable fish found within our waters. Its use as a manure is well known in the counties of Suffolk, Kings, and Queens, where it is a source of great wealth to the farmer who lives upon the sea-coast. They are used in various ways: for Indian corn, two or three are thrown on a hill; for wheat, they are thrown broadcast on the field, and plowed under; although it is not uncommon to put them in layers alternately with common mold, and when decomposed spread it like any other compost. Its effects in renovating old grass-fields, when spread over with these fish at the rate of about two thousand to the acre, are very remarkable. Its value, however, as a manure has one drawback in the abominable and unhealthy stench which poisons the whole country, and, according to the testimony of some medical writers, lays the foundation of dysenteries and autumnal fevers. They appear on the shores of Long Island about the beginning of June, in immense schools; and as they frequently swim with a part of the head above or near the surface of the water, they are readily seen and captured. They are commonly sold on the spot at the rate of $2 the wagon-load, containing about a thousand fish. The largest haul I remember to have heard of was through the surf at Bridgehampton, at the east end of the island. Eighty-four wagon loads, or, in other words, 84,000 of these fish were taken at a single haul. On the coast of Massachusetts they are used as bait for mackerel, cod, and halibut; and many are packed away for exportation to the West Indies. According to Dr. Storer, in 1836, 1,488 barrels were thus salted down for exportation. I am not aware that its geographical limits pass beyond the coast of New Hampshire on one side, and Chesapeake Bay on the other.

[From Cuvier and Valenciennes' "Histoire Naturelle des Poissons," vol. xx, p. 424.]

L'ALOSE MENHADEN. (*Alausa menhaden*, nob.)

Cette clupée, très abondante aux Etats-Unis, l'un des produits considérables des vastes fleuves de cette contrée, est éminemment remarquable par la grosseur de sa tête et par la hauteur de la région pectorale du tronc; elle égale trois fois et demie la hauteur de la queue. La longueur de la tête surpasse en quelque peu cette hauteur, et elle est comprise trois fois dans la distance entre le bout du museau et la naissance de la caudale Ces proportions moutrent que le corps est extrémement trapu. La mâchoire supérieure ne dépasse pas l'inférieure. L'oeil est recouvert d'une double paupiére adipeuse três-épaisse. L'opercule a de fines stries et de jolies très agréablment ramifiées. De fines stries rayonnantes couvrent l'opercule; il y en a aussi vers le bas du préopercule. Le sous-opercule et l'interopercule sont très grands. La ceinture humérale est étroite. La dorsale est sur le milieu de la longueur du tronc. Les nombres des rayons de ces nageoires ne diffèrent pas de ceux des autres espèces.

D. 19; A. 19; C. 27; P. 15; V. 7.

Les écailles sont finement et longument ciliées. Leur portion libre est petite; la partie radicale a des stries verticales et parallèles au bord. De chaque côté du dos on remarque deux rangées d'écailles beaucoup plus profondément ciliées, et que, en s'enchevêtrant sur la ligne moyenne, forment une singulière gouttière le long de cette ligne. Des écailles membraneuses font une gouttière assez profonde, dans laquelle s'engage la dorsale. Une tache d'un bleu foncé existe sur le haut de l'epaule, et se conserve parfaitement sur les individus gardés depuis longtemps dans l'alcool. Le dos est verdâtre; tout le reste du poisson brille d'un vif éclat argenté. Nous avons recu de nombreux individus de cette espèce. Les plus grands n'ont que treize a quatorze pouces. M. M. Milbert et Lesueur les ont envoyés en abondance des marchés de New York et de Philadelphie. M. Bosc avait rapporté l'espèce de la Caroline, et récemment M. Holbroock m'en a envoyé d'autres exemplaires des marchés de Charlestown. Enfin, M. le comte de Castélman en a convoyé de l'embouchure de l' Hudson.

L'espèce a paru pour la première fois dans le mémoire de M. Mitchill sous le nom que nous lui conservons. Nous la retrouvons dans les ouvrages de MM. Storer et Dekay. Celui-ci en a donné une bell figure, et le premier de ces auteurs a fait connaître le nombre considérable de barils que l'on exporte chaque année. Comme c'est un poisson très huileux, on s'en sert plutôt comme engrais ou comme amorce, surtout pour les grands Flétans (*Peuronectes hippoglossus*). C'est sous ce rapport qu'il devient l'objet d'un commerce considérable. Au nom de Menhaden, qui est une de ses dénominations vulgaries, il faut ajouter celle de *Panhagen* et de *Mossbonkers* ou de *Bonyfish*, etc.

[From Uhler & Lugger's List of the Fishes of Maryland, 1876, p. 133.]

BREVOORTIA MENHADEN. Ale-wife, or Menhaden.

Body elongated, compressed. Its depth across, at the base of the pectorals, less than one-fifth the length of the fish; length of the head more than one-third the length of it. Gill-covers very large. Upper part of body greenish-brown, darker upon the top of the head and at the snout; upper part of the sides in the living fish rose-colored and mottled with blue, which disappear in death; abdomen silvery; a black spot, more or less distinct, upon the shoulders; whole surface of the fish iridescent.

Length 10 to 14 inches.

Fin-rays: D. 19; P. 15–17; V. 6; A. 18–22; C. 20.

B. menhaden, MITCH., Lit. and Phil. Trans. New York, i. p. 453, pl. 5, fig. 7.
Alosa menhaden, Storer, Report Fish. Massach., p. 117; DEKAY, York Faun., Fish., p. 259, pl. 21, fig. 60; AYERS, Boston Jour. Nat. Hist., iv, p. 275; STORER, Mem. Am. Ac., vi. p. 337, pl. 26, fig. 3.
Brevoortia menhaden, GILL., Proc. Ac. Nat. Sc. Philad., 1861, p. 37.

Common on the Atlantic coast of Worcester County and even entering Sinepuxent Bay, also in vast shoals in Chesapeake Bay, particularly about the mouths of the great rivers of both peninsulas. They have been extensively used for manure by the farmers living near the coast, where they are caught by untold thousands in the large seines.

Acad. Coll. S. I.

[From Perley's Reports on the Sea and River Fisheries of New Brunswick, 1852, p. 208.]

SPECIES 3.—*Alosa menhaden*—THE MOSSBONKER.

This fish is known by a variety of popular names, among which are "bony-fish," "hard-head," "pauhagen," and "menhaden." It is seldom eaten, being dry, without flavor, and full of bones. On the coast of the United States it is used as bait for cod, and also extensively as manure for renovating old grass-fields, but not without injury to the health of those who reside in the vicinity. The mossbonker is sometimes caught in the weirs, within the harbor of Saint John, in considerable numbers; it has occasionally been sold to the ignorant for fall shad, to which it bears some resemblance. The mossbonker is exclusively a sea-fish, never entering the fresh water.

[From Gray's "Catalogue of Fish, collected and described by Lawrence Theodore Gronow, now in the British Museum," 1854, p. 140.]

CLUPEA CAROLINENSIS—M. G. B. M.

Clupea immaculata argentea abdomine anteriore prominulo dentato: lateribus amplissimis.

Habitat gregatim ad Carolinam Meridionalem.

Longitudo tota quinque pollicaris et altitudo maxima paulo ante pinnam dorsalem est unius polliciscum deinidio.

Dorsum rectum, convexum, capitiparrellelum. *Caput* cathetoplateum, cranium rectum convexiusculum; utringue compressum subtus augustatum carinatum adscendens a juncturis branchiarum versus os. *Oculi* magni, ori proximi: mystaces lalissimæ oseæ pellucidæ inermes *Maxilla inferior* augusta, acuminata, oblique sursum spectans, ad superiorem adductilis. *Opercula* planiuscula, latissima, splendedissima rotundatetruncata. *Latera* planiuscula, obliquata, mox post pinnas pectorales latissima, versus caudam gracilescentia. *Abdomen* carinatum valde prominens, squamis denticulato-serratum. *Color* argenteus splendens, in dorso cœrulescens. *Linea lateralis* nulla. *Squamæ* imbricatim sitæ, latæ, deciduæ. *Prima Dorsi* in medio dorso parva radiis 18. *Pectorales* in imo pectore radiis 17. *Ventrales* approximatæ parvæ in imo ventre, initio dorsalis oppositæ medio inter ventrales et analem, radiis sex. *Analis* humilis, medio inter ventrales et caudam, radiis 18, sensim decrescentibus. *Cauda* profunde bifurcata, lobis æqualibus acuminatis, radiis contiguis, subramosis. Latitudine laterum præsertim ab Harengo B differre videtur.

[From Günther's "Catalogue of the Fishes in the British Museum," vol. vii, p. 436.]

CLUPEA MENHADEN. Mossbanker.

Clupea menhaden, MITCH., *Lit. & Phil. Trans., New York*, i, p. 453, pl. 5, fig. 7.

Alosa menhaden, STORER, *Report Fish. Massach.*, p. 117; DEKAY, *N. York Faun.*, p. 259, pl. 21, fig. 60; AYERS, *Bost. Journ. Nat. Hist.*, iv, p. 275; CUV. & VAL., xx, p. 424; STORER, *Mem. Am. Ac.*, vi, p. 337, pl. 26, fig. 3.

——— *sadina*, DEKAY, *l. c.*, p. 263, pl. 40, fig. 129. MITCHILL'S *Clupea sadina* (Trans. Lit. & Phil. Soc. New York, i, p. 457) was evidently a different fish, which, however cannot be determined at present.

Clupea carolinensis, GRONOV, *Syst.*, ed. Gray, p. 140.

Brevoortia menhaden, GILL, *Proc. Ac. Nat. Sc. Philad.*, 1861, p. 37. (Name only.)

D 19; A. 19–20; V. 7.

Scales irregularly arranged; their free portion is very narrow and deep, with the margin ciliated. *The height of the body is rather less* than the length of *the head, which is one-third of the total* (*without caudal*). Lower jaw shutting within the upper; maxillary reaching to the vertical from the hind margin of the orbit. No teeth on the palate or tongue. Operculum finely striated; suboperculum large, tapering above. Gill-rakers very fine and exceedingly long; the horizontal branch of the outer branchial arch consists of two portions joined at an obtuse angle. Ventral fins opposite to the anterior third of the dorsal, the origin of which is somewhat nearer to the caudal than to the end of the snout. Basil half of the caudal fin covered with small scales. There are from twelve to thirteen abdominal scutes behind the base of the ventral fins. A blackish blotch in the scapulary region.

Atlantic coast of the United States.

a, *b*, Adult New York. Purchased of Mr. Brandt. *c*, *d*, Half-grown and young; skins; New York. From Mr. Parnell's collection. *e*, *f*, Young, North America. Presented by E. Doubleday, esq. *g*, Young. Old collection (*Clupea smaragdina*). *h*, Young; skin. From Gronow's collection. Type of *Clupea carolinensis*.

APPENDIX E.

CATALOGUE OF SPECIMENS IN THE NATIONAL MUSEUM.

Catalogue number.	Sex and age.	Locality.	When collected.	Collected by—	Nature of specimen.	Remarks.
16369	Young	Wood's Holl, Mass.		United States Fish Commission.	Alcoholic	
12831	do	Washington, D. C.		Captain Evans	do	
13369	do	Wood's Holl, Mass.		United States Fish Commission.	do	
13356	do	do		do	do	
15055	do				do	
13370	do	Wood's Holl, Mass.		United States Fish Commission.	do	
13371	do	do		do	do	
13372	do	do		do	do	
13365	do	do		do	do	
19146	do	do		Vinal N. Edwards.	do	
16378	do	Robinson's Holl, Mass		United States Fish Commission.	do	
13368	do	Wood's Holl, Mass.		do	do	
13359	do	do		do	do	
20013	do	do		Vinal N. Edwards.	do	
5055	do	do		S. F. Baird	do	
13373	do	do		United States Fish Commission.	do	
13363	do	do		do	do	
20630	do	do		Vinal N. Edwards.	do	
16386	do	do		United States Fish Commission.	do	
13357	do	do		do	do	
14133	do	Noank, Conn.		do	do	
13362	do	Wood's Holl, Mass.		do	do	
16368	do	do		do	do	
13360	do	do		do	do	
20616	do	do		Vinal N. Edwards.	do	
14136	do	Noank, Conn.		United States Fish Commission.	do	
13361	do	Wood's Holl, Mass		do	do	
15218		Noank, Conn		do	Stomach	
13374	do	Wood's Holl, Mass.		do	Alcoholic	
13375	do	Menemsha Bight, Mass.		do	do	
14817	do	Wood's Holl, Mass.		do	do	
14139		do		do	Ovaries	
13364	do	do		do	Alcoholic	
20380	do	do		Vinal N. Edwards.	do	
13367	do	do		United States Fish Commission.	do	
13358	do	do		do	do	
20679	do	do		Vinal N. Edwards.	do	
20606	do	do		do	do	
10405	Ad	do		S. F. Baird	do	709 C. A. S.
5152	Young	West Florida		Kaiser and Martin.	do	
892		Brazos Santiago, Tex		Capt. Van Vliet	do	
5864				New Orleans Academy.	do	
891		Mouth Rio Grande		Emory & Clark	do	
7696		Indian River		Wurdemann	do	
5948		Mississippi		B. L. C. Wails	do	
15217		Noank, Conn	Aug. 24, 1874	United States Fish Commission.	Ovaries	
16947		Maine	Aug. 20, 1876	S. L. Goodale	do	
16946		do	Sept. 14, 1876	do	do	

Catalogue of specimens in the National Museum—Continued.

Catalogue number.	Sex and age.	Locality.	When collected.	Collected by—	Nature of specimen.	Remarks.
396	....	Fort Brown, Tex	——, 1858	Major Emory	Alcoholic ...	
13355	....	Wood's Holl, Mass ...	Sept. 26, 1874	United States Fish Commission.	....do	
13366	....	......do	Sept. 4, 1874	....do	....do	
14044	....	Noank, Conn	——, 1874	....do	....do	
14128	....	......do	July 29, 1874	....do	....do	Ovaries.
14845	....	......do	——, 1874	....do	....do	
14846	....	......do	....do	....do	....do	
16013	....	Wood's Holl, Mass ...	July 2, 1875	....do	....do	
16015	....	......do	....do	....do	....do	
16014	....	......do	....do	....do	....do	
16033	....	Buzzard's Bay	——, 1875	....do	....do	
16198	....	Wood's Holl, Mass ..	June 10, 1875	....do	....do	Ovaries, &c.
16313	....	......do	Aug. 4, 1875	....do	....do	Color sketch.
16363	....	......do	Aug. 5, 1875	....do	....do	
16367	....	......do	....do	....do	....do	
16463	....	Menemsha Bight, Mass.	Aug. 3, 1875	....do	....do	
16596	....	......do	Sept. 5, 1875	....do	....do	
16796	....	....	——, 1876	....do	....do	Cast No. 567.
17927	....	Saint John's River, Fla.	Apr. 2, 1877	S. F. Baird	....do	
18049	....	......do	....	....do	....do	
19042	....	Florida	——, 1875	G. Brown Goode ...	....do	
19043	....	......do	....do	....do	....do	
19044	....	......do	....do	....do	....do	
19045	....	......do	....do	....do	....do	
19046	....	......do	....do	....do	....do	
19137	....	Wood's Holl, Mass ...	——, 1876	Vinal N. Edwards.	....do	
19359	....	......do	——, 1875	United States Fish Commission.	....do	
19360	....	......do	....do	....do	....do	
19361	....	......do	....do	....do	....do	
19362	....	......do	....do	....do	....do	
19363	....	......do	....do	....do	....do	
19364	....	......do	....do	....do	....do	
19457	....	Potomac River	May —, 1875	Milner and Goode	....do	
19468	....	Eastern Shore of Virginia.	——, 1875	Prof. H. E. Webster	....do	
19682	....	Beaufort, N. C	——, 1872	Dr. H. C. Yarrow ...	....do	
19918	....	....	....	....	....do	
20016	....	Wood's Holl, Mass ...	——, 1876	Vinal N. Edwards	....do	
20287	....	......do	....	....do	....do	
20516	....	Menemsha Bight, Mass.	——, 1875	United States Fish Commission.	....do	
20603	....	Wood's Holl, Mass ...	Oct. 2, 1877	....do	....do	
20887	....	......do	Nov. 24, 1877	....do	....do	
10696	....	Wood's Holl, Mass ..	....	United States Fish Commission.	Cast	
16313	....	......do	Aug. 1, 1875	....do	....do	
16796	....	....	1876	....do	....do	

Photographs.—257, 258, 259, 260, 386, 387.—UNITED STATES FISH COMMISSION.

APPENDIX F.

TABLES SHOWING MONTHLY MEANS OF TEMPERATURE FOR CERTAIN POINTS ON THE ATLANTIC COAST OF THE UNITED STATES FOR THE YEAR INCLUDED BETWEEN MARCH 1, 1876, AND MARCH 1, 1877.

TABLE I.—*Table of surface temperatures, March, 1876, to February, 1877, inclusive, at 3 p. m.*

Place of observation.	Spring.				Summer.				Autumn.				Winter.				Year ending February, 1877.
	March, 1876.	April, 1876.	May, 1876.	Quarter ending May, 1876.	June, 1876.	July, 1876.	August, 1876.	Quarter ending August, 1876.	September, 1876.	October, 1876.	November, 1876.	Quarter ending November, 1876.	December, 1876.	January, 1877.	February, 1877.	Quarter ending February, 1877.	
Eastport, Me	32.5	35.3	38.4	35.4	42.7	47.2	50.2	46.7	50.6	50	(46.1)	(48.9)	40.1	31.5	29.8	33.8	41.0
Portland, Me	33.9	(38.1)	(47.3)	(39.7)	56.9	66.7	63.9	62.5	57.1	50.3	44.9	50.7	34.5	30.6	33.9	33	46.4
Wood's Holl, Mass	34.3	43.2	52.3	43.2	67.4	75.1	72.4	71.6		56.4	48	(52.2)	34.3	29.9	31.4	31.8	49.5
New London, Conn	38	46.1	56.8	46.9	69.2	73	73.3	71.8	65.5	57.2	49.7	57.7	38.2	33.8	36.2	36	52.6
New York, N. Y	33.5	39.6	51	41.3	68.1	72.2	72.5	70.9	64.5	53	47	54.8	(32.3)	28.2	32.4	(30.9)	49.4
Baltimore, Md	42	51.5	64.5	52.6	77.1	84.1	78.3	79.8	70.7	58	50.8	59.8	35	32.2		(33.6)	56.4
Norfolk, Va	48.8	57.6	67.9	58	79.6	84.4	78.1	80.7	(69.2)	60.5	53.8	(61.1)	36.8	38.6	44	39.8	59.9
Kitty Hawk, N. C					(72.8)	73.1	78.5	(74.8)	72.4								
Wilmington, N. C	55.3	61.9	71.7	62.9	75.3	81.3	80.3	78.9	77.3	64.1	58.2	66.5	44.5	41.9	50.1	45.5	63.4
Charleston, S. C	59.1	64.3	72.8	65.4	79.4	85.3	(85.6)	83.4	81.1	64.5	60.8	68.8	46.6	48.3	52.2	49	66.6
Savannah, Ga	56.5	60.5	67.2	61.4	72	(77.6)	83	77.5	81.3		(53.6)	(67.4)	44.4	48.9	51.7	48	63.8
Jacksonville, Fla	(64.8)	73.1	80.9	(72.9)	85.2	88.3	88.2	87.2	86.1	72.6	(67.3)	(75.3)	(51.2)	56.6	58.9	(55.5)	72.7
Key West, Fla	75.4	78.5	83.1	79	86.6	86.4	86.4	86.4	87.7	81.5	74.2	81.1	66.4	73.1	69.3	69.6	79

TABLE II.—*Table of bottom temperatures March, 1876, to February, 1877, inclusive, 3 p. m.*

Place of observation.	Spring.				Summer.				Autumn.				Winter.				Year ending February 28, 1877.
	March, 1876.	April, 1876.	May, 1876.	Quarter ending May 31, 1876.	June, 1876.	July, 1876.	August, 1876.	Quarter ending August 31, 1876.	September, 1876.	October, 1876.	November, 1876.	Quarter ending November 30, 1876.	December, 1876.	January, 1877.	February, 1877.	Quarter ending February 28, 1877.	
Eastport, Me	32.1	34.9	37.9	34.9	41.7	45.8	49	45.5	50.1	49.8	45.9	48.6	39	31	29.2	33	40.5
Portland, Me	33.3	37	44	38.1	54	59.4	60.4	57.9	55.3	48.8	44.3	49.4	35	30.5	33	32.8	44.5
Wood's Holl, Mass	33.5	42.9	51.5	42.6	65.5	74.2	71.6	70.4	66.3	56.2	47.6	56.7	33.1	29.2	31.3	31.2	50.2
New London, Conn	37	42.7	50.6	43.4	61.3	68.7	74.2	68	65.3	57.3	50.6	57.7	39	34	34.9	35.9	52.2
New York, N. Y	32.8	39.2	50.2	40.7	66.8	70.9	72	69.9	64.3	52.4	46.1	54.2	32.4	28.1	32.1	30.8	48.9
Baltimore, Md	41.3	50.7	63.4	51.8	76.8	83.2	72.1	77.3	70.5	57.8	50.4	59.5	34.9	32.1	.....	33	.....
Norfolk, Va	48.2	56.9	67.4	57.5	78.7	80.3	77.3	78.7	66.1	59.8	53.4	59.7	36.4	37.6	42.9	38.9	58.7
Kitty Hawk, N. C	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wilmington, N. C	55	61.7	71.3	69.3	75	81.1	80.2	78.7	77.2	66.4	57.1	66.9	43.1	43	48.5	44.8	64.9
Charleston, S. C	58	63.9	72.5	64.7	80.4	85	84.2	83.2	81	67	60.9	69.6	46.7	48.2	52.2	49	66.6
Savannah, Ga	56.2	59.8	66.8	60.9	71.7	76.8	82.7	77	80.7	.....	53	.....	43.8	47.9	51.3	47.6	.....
Jacksonville, Fla	64.7	73.6	80.9	72.7	84.9	88.3	87.2	86.8	85.8	72.5	68.2	75.5	51.3	56.5	58.7	55.5	72.6
Key West, Fla	75	79	82.3	76	85.6	86	85.5	85.7	87	81	73.6	80.5	66.2	72.5	68.6	69.1	77.8

TABLE III.—*Table of mean temperatures of surface and bottom, March, 1876, to February, 1877, inclusive.*

Place of observation.	Spring.				Summer.				Autumn.				Winter.				Year ending February 28, 1877.
	March, 1876.	April, 1876.	May, 1876.	Quarter ending May 31, 1876.	June, 1876.	July, 1876.	August, 1876.	Quarter ending August 31, 1876.	September, 1876.	October, 1876.	November, 1876.	Quarter ending November 30, 1876.	December, 1876.	January, 1877.	February, 1877.	Quarter ending February 28, 1877.	
Eastport, Me	32.3	35.1	38.1	35.1	41.7	46.5	49.6	46.1	50.3	49.9	46	48.7	39.5	31.2	29.5	33.4	40.8
Portland, Me	33.6	37.5	45.6	38.9	55.4	63	62.1	60.2	56.2	49.5	44.6	50	34.7	30.5	33.4	32.9	45.5
Wood's Holl, Mass	33.9	43	51.9	42.9	66.4	74.6	72	71	......	56.3	47.8	54.4	33.7	29.5	31.3	31.5	49.9
New London, Conn	37.5	44.4	53.7	45.1	65.2	70.8	73.7	69.9	65.4	57.2	50.1	57.7	38.6	33.9	35.5	35.9	52.1
New York, N. Y	33.1	39.4	50.6	41	67.4	71.5	72.2	70.4	64.4	52.7	46.5	54.5	32.3	28.1	32.2	30.8	49.1
Baltimore, Md	41.6	50.8	63.9	51.7	76.9	83.6	75.2	78.5	70.6	57.9	50.6	59.6	34.9	32.1	......	33.3	55.7
Norfolk, Va	48.5	57.2	67.6	57.7	79.1	82.3	77.7	79.7	67.6	60.1	53.6	60.4	36.6	38.1	43.4	39.3	59.2
Kitty Hawk, N. C	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Wilmington, N. C	55.1	61.8	71.5	66.1	75.1	81.2	80.2	78.8	77.2	65.2	57.6	66.7	43.8	42.4	49.3	45.1	64.1
Charleston, S. C	58.5	64.1	72.6	65	79.9	85.1	84.9	83.3	81	65.7	60.8	64.2	46.6	48.2	52.2	49	65.3
Savannah, Ga	56.3	60.1	67	61.1	71.8	77.2	82.8	77.2	81	......	53.3	......	44.2	48.4	51.5	47.8	......
Jacksonville, Fla	64.7	73.3	80.9	77.8	85	88.3	87.5	87	85.9	72.6	67.7	75.5	51	56.5	58.8	55.5	73.9
Kew West, Fla	75.2	78.7	82.7	77.5	86.1	86.2	85.9	86	87.3	81.2	73.9	80.8	66.3	72.8	68.9	69.3	78.4

TABLE IV.—*Table of mean temperatures of surface and bottom, March, 1877, to February 28, 1878, inclusive.*

Place of observation.	Spring.				Summer.				Autumn.				Winter.			
	March, 1877.	April, 1877.	May, 1877.	Quarter ending May 31, 1877.	June, 1877.	July, 1877.	August, 1877.	Quarter ending August 31, 1877.	September, 1877.	October, 1877.	November, 1877.	Quarter ending November 30, 1877.	December, 1877.	January, 1878.	February, 1878.	Quarter ending February 28, 1878.
Eastport, Me	......	32.4	......	......	39.4	43	46.1	42.8	48.7	47.4	45.8	47.3	41.8	36.8	......	......
Portland, Me	......	41.5	......	......	54.1	57.2	61	57.6	58.7	51.9	45.3	51.9	40.2	33.5	......	......
Wood's Holl, Mass	......	43	......	......	63.9	68.3	70.9	67.7	68.8	......	49.7	......	42	......	......	......
New London, Conn	......	44.6	......	......	62.2	67.5	71	66.9	67.2	59.7	49.9	58.9	43.5	37.5	......	......
New York, N. Y	......	41.6	......	......	62.6	......	73	......	67.6	59	47.3	57.9	39.3	33.8	......	......
Baltimore, Md	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Norfolk, Va	......	56.1	......	......	73.3	79.4	79	77.2	70.3	62	53.9	62	43	35	......	......
Kitty Hawk, N. C	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Wilmington, N. C	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Charleston, S. C	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Savannah, Ga	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Jacksonville, Fla	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Key West, Fla	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

APPENDIX G.

A TABLE SHOWING COMPARATIVE AMOUNTS OF MENHADEN, MACKEREL, SHAD, ALEWIVES INSPECTED IN THE STATE OF MASSACHUSETTS.

MASSACHUSETTS INSPECTIONS.

Years.	Shad.	Alewives.	Menhaden.	Mackerel.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
1804	57	4, 551$\frac{1}{2}$	3, 642$\frac{1}{2}$	7, 857$\frac{1}{2}$
1805	186$\frac{1}{2}$	4, 069	3, 416	8, 533$\frac{1}{2}$
1806	50	4, 518$\frac{1}{2}$	4, 951$\frac{1}{2}$	8, 226$\frac{1}{2}$
1807	22	7, 638$\frac{1}{2}$	3, 786$\frac{1}{2}$	9, 305
1808	147	1, 085	1, 306	7, 629$\frac{1}{2}$
1809	311	7, 287	3, 024	8, 825
1810	201	6, 524$\frac{1}{2}$	2, 524	12, 552$\frac{1}{2}$
1811	1, 443	5, 889$\frac{1}{2}$	7, 148	17, 401
1812	822	4, 971	1, 155	5, 881
1813	822$\frac{1}{2}$	1, 908$\frac{1}{2}$	90$\frac{1}{2}$	3, 756$\frac{1}{2}$
1814	214	673	10$\frac{1}{4}$	1, 339
1815	526	1, 770$\frac{1}{2}$	2, 306	16, 059$\frac{1}{2}$
1816	379$\frac{1}{2}$	1, 593	3, 945	31, 269
1817	461$\frac{1}{2}$	1, 440	4, 238	37, 362
1818	244	998$\frac{1}{2}$	4, 512	46, 348
1819	93$\frac{1}{2}$	792$\frac{1}{2}$	4, 640$\frac{1}{2}$	100, 101
1820	59$\frac{1}{2}$	476$\frac{1}{2}$	1, 338	115, 641
1821	21$\frac{1}{2}$	642$\frac{1}{2}$	551	111, 009$\frac{1}{2}$
1822	41	2, 155$\frac{1}{2}$	237	160, 294$\frac{1}{2}$
1823	63	3, 967$\frac{1}{2}$	365	145, 006
1824	53$\frac{1}{2}$	4, 037	987	191, 650$\frac{1}{2}$
1825	364	3, 653	697	254, 384$\frac{1}{2}$
1826	313	2, 938	224	158, 740$\frac{1}{2}$
1827	283	1, 864	164	190, 304$\frac{1}{2}$
1828	607	2, 731	358	237, 324$\frac{1}{2}$
1829	653$\frac{1}{2}$	3, 437	236	225, 977$\frac{1}{2}$
1830	152$\frac{1}{2}$	3, 030	97	308, 463$\frac{1}{2}$
1831	1, 062$\frac{1}{2}$	3, 036	1, 147	383, 548$\frac{1}{2}$
1832	105	1, 755	300	222, 452
1833	321	2, 266	480	222, 932$\frac{1}{2}$
1834	3	4, 315$\frac{1}{2}$	1, 008	252, 879$\frac{1}{2}$
1835	309$\frac{1}{2}$	5, 685$\frac{1}{2}$	1, 443	194, 800$\frac{1}{2}$
1836	527	4, 979	1, 488	174, 410$\frac{1}{2}$
1837	652	1, 182	461	138, 157$\frac{1}{2}$
1838	390	604	1, 164	110, 740$\frac{1}{4}$
1839	773	2, 769	10, 883	74, 268$\frac{1}{4}$
1840	856	1, 474	1, 427	50, 491$\frac{1}{2}$
1841	3, 910	2, 840	2, 138	55, 537
1842	2, 831	7, 196	566	75, 543
1843	903	5, 554	854	64, 451
1844	1, 679	6, 308	476	86, 381$\frac{1}{2}$
1845	1, 377	4, 714	272	202, 302$\frac{3}{4}$
1846	517	2, 626$\frac{1}{2}$	585	179, 311$\frac{7}{8}$
1847	474	3, 843	132	251, 917$\frac{1}{2}$
1848	228$\frac{3}{4}$	1, 899$\frac{1}{4}$	137	300, 130$\frac{5}{8}$
1849	331	2, 152	78	208, 950
1850	502	1, 629	137	242, 572
1851	180$\frac{3}{4}$	1, 358$\frac{1}{2}$	....	329, 244$\frac{1}{8}$
1852	195	1, 604	107	198, 120
1853	16$\frac{5}{8}$	1, 580	....	133, 340$\frac{1}{4}$
1854	225$\frac{3}{8}$	1, 645	....	135, 349$\frac{3}{4}$
1855	238$\frac{1}{2}$	2, 775	....	211, 956$\frac{5}{8}$
1856	265	2, 740$\frac{1}{2}$	63	214, 312
1857	473$\frac{1}{2}$	2, 497	203	168, 705$\frac{5}{8}$
1858	197$\frac{1}{2}$	2, 895$\frac{1}{2}$	....	131, 602$\frac{5}{16}$
1859	421$\frac{3}{4}$	2, 499$\frac{1}{2}$	600	99, 715$\frac{3}{4}$
1860	487$\frac{6}{8}$	1, 604	360	235, 685$\frac{3}{4}$
1861	73$\frac{5}{8}$	355	....	194, 283$\frac{5}{8}$
1862	61$\frac{1}{8}$	821$\frac{1}{2}$	250	260, 864$\frac{7}{8}$
1863	56$\frac{5}{8}$	589	425	306, 942$\frac{9}{16}$
1864	20	390	....	274, 357$\frac{1}{4}$
1865	26$\frac{1}{4}$	511	630	256, 796$\frac{1}{8}$
1866	10$\frac{1}{4}$	592	6$\frac{1}{4}$	231, 696$\frac{7}{16}$
1867	103$\frac{3}{8}$	342$\frac{1}{2}$	250	210, 314$\frac{1}{16}$
1868	2$\frac{1}{2}$	118	....	180, 056$\frac{11}{80}$
1869	....	87$\frac{3}{4}$	....	234, 210$\frac{7}{8}$
1870	....	65$\frac{7}{8}$	450	318, 521$\frac{3}{5}$
1871	12$\frac{1}{2}$	56	229	259, 416$\frac{3}{4}$
1872	15$\frac{9}{20}$	424	....	181, 956$\frac{1}{80}$
1873	2$\frac{1}{4}$	550	....	185, 748$\frac{1}{2}$
1874	14$\frac{3}{8}$	308	290	258, 379$\frac{15}{16}$
1875	65$\frac{1}{4}$	269$\frac{1}{2}$	....	130, 062$\frac{71}{80}$
1876	76$\frac{3}{4}$	388$\frac{1}{2}$	9	225, 942$\frac{17}{80}$
1877	$\frac{1}{4}$	357$\frac{1}{4}$	52	105, 097$\frac{3}{5}$

APPENDIX H.

LIST OF MANUFACTURERS OF MENHADEN OIL AND GUANO, 1877.

[The following table was furnished by Mr. Jasper Pryer.]

Name of manufacturer.	Location of factory.	Winter address.
G. S. Allyn & Co	Mystic River, Conn	Mystic River, Conn.
O. H. Almy & Co. (E. J. Corey, agent)	Tiverton Four Corners, R. I.	Tiverton Four Corners, R. I.
Barren Island Manufacturing Company	Barren Island, N. Y	58 Broad street, New York City.
William J. Brightman & Co	Tiverton, R. I	Tiverton, R. I.
J. H. Bishop	Madison, Conn	Madison, Conn.
Bristol Oil Works	Round Pond, Me	Round Pond, Me.
Brown's Cove Company	do	Do.
Isaac Brown & Co	Tiverton, R. I	Tiverton, R. I.
Nelson Burnett	Southampton, N. Y	Southampton, N. Y.
Cape Cod Oil Works (J. Cook)	Provincetown, Mass	Provincetown, Mass.
B. C. Cartwright	Shelter Island, N. Y	Shelter Island, N. Y.
Joseph Church & Co	Round Pond, Me	Tiverton, R. I.
G. H. Clark	East Marion, N. Y	East Marion, N. Y.
Charles Cook	Tiverton Four Corners, R. I.	Tiverton Four Corners, R. I.
Captain C. Doughty	Somers Point, N. J	Somers Point, N. J.
W. Y. Fithian & Co	Amagansett, N. Y	Southold, N. Y.
Robert A. Friend	Brooklin, Me	Brooklin, Me.
Ford, Avery & Co	Tangier Island, Md	
Fowler, Foot & Co	South Bristol, Me	Guilford, Conn.
Gallup & Holmes	Boothbay, Me	Groton, Conn.
Gallup, Morgan & Co	do	Do.
Albert Gray & Co	Round Pond, Me	Tiverton, R. I.
Thomas F. Gray	Tiverton, R. I	Do.
W. H. H. Glover	Southold, N. Y	Southold, N. Y.
Green Brothers	Amagansett, N. Y	Davisville, R. I.
Griffin & Vail	Port Monmouth, N. J	Riverhead, N. Y.
W. D. Hall	Millenbeck, Va	Millenbeck, Va.
F. J. Harker	Hampton, Va	Hampton, Va.
J. S. Havens	Patchogue, N. Y	Moriches, N. Y.
Hawkins Brothers	Shelter Island, N. Y	Jamesport, N. Y.
Hawkins Brothers	Barren Island, N. Y	Do.
W. H. H. Howland	Portsmouth, R. I	Tiverton, R. I.
Seaman Jones & Co	Barren Island, N. Y	134 Third avenue, New York City.
E. K. Kelsey	Branford, Conn	Clinton, Conn.
Kenniston, Cobb & Co	Booth Bay, Me	Boothbay, Me.
Loud's Island Oil Company	Round Pond, Me	Round Pond, Me.
Luce Brothers	Niantic, Conn	East Lyme, Conn.
Maddocks' Oil-Works	Booth Bay, Me	Boothbay, Me.
Manokin Oil-Works	Somerset County, Md	
Anthony Manchester	Tiverton Four Corners, R. I.	Tiverton Four Corners, R. I.
B. F. Manchester	Somers Point, N. J	Somers Point, N. J.
James Manchester	Tiverton, R. I	Tiverton, R. I.
The George W. Miles Company	South Bristol, Me	Milford, Conn.
Morris & Fifield	Somers Point, N. J	Somer's Point, N. J.
North American Oil-Works	Wellfleet, Mass	Wellfleet, Mass.
James E. Otis	Tuckerton, N. J	Saybrook, Conn.
Pemaquid Oil-Works	Bristol, Me	Bristol, Me.
Erskine Pierce	Dartmouth, Mass	Dartmouth, Mass.
F. F. Pierce	Greenport, N. Y	Greenport, N. Y.
Joseph D. Parsons	Springs, N. Y	Springs, N. Y.
G. H. Payne	Deep Hole, Easthampton, N. Y	Sag Harbor, N. Y.
Quinnipiac Fertilizer Company (H. L. Dudley, agent.)	Pine Island, Conn	New Haven, Conn.
J. Harrison Raynor	Greenport, N. Y	Greenport, N. Y.
W. C. Raynor	Westhampton, N. Y	Westhampton, N. Y.
Round Pond Oil-Works	Round Pond, Me	Round Pond, Me.
Amasa Simmons (Herman Smith, agent)	Tiverton Four Corners, R. I.	Tiverton Four Corners, R. I.
Cyrus H. Smith	Tuckerton, N. J	Tuckerton, N. J.
Smith, Green & Co	Sayville, N. Y	Sayville, N. Y.
Smith & Yarrington	do	Do.
South Bay Oil Company	do	Do.
South St. George Oil-Works	South Saint George, Me	South Saint George, Me.
John Southworth	Portsmouth, R. I	Fall River, Mass.
Suffolk Oil Company	Boothbay, Me	Boston, Mass.
Tuthill, French & Co	East South Bristol, Me	Greenport, N. Y.
George F. Tuthill	Greenport, N. Y	Do.
Virginia Oil & Guano Company (O. E. Maltby, president.)	Norfolk, Va	Norfolk, Va.
Benjamin Waites	Tiverton Four Corners, R. I.	Tiverton Four Corners, R. I.
Waley & Co	Poquonnock Bridge, Conn	Poquonnock Bridge, Conn.
Wells & Co	South Bristol, Me	Greenport, N. Y.
Isaac G. White	Tiverton Four Corners, R. I.	Tiverton Four Corners, R. I.
Wilcox & Manchester	do	Do.

List of manufacturers of menhaden oil and guano, 1877—Continued.

Name of manufacturer.	Location of factory.	Winter address.
Leander Wilcox & Co	Mystic Bridge, Conn	Mystic Bridge, Conn.
Job T. Wilson	Fall River, Mass	Fall River, Mass.
W. W. Warner	Good Ground, N. Y	Good Ground, N. Y.
Henry E. Wells	Greenport, N. Y	Greenport, N. Y.
Westbrook Oil Company	Westbrook, Conn	Westbrook, Conn.

APPENDIX I.

PARTIAL LIST OF VESSELS EMPLOYED IN THE MENHADEN FISHERY.

STEAMERS.

Name.	Tonnage.	Owner.	Port of entry.	Where fishing.
Mabel Bird	80	L. Maddocks	Boothbay, Me	Maine.
M. W. Fish	80	do	do	Do.
Grace Darle	85	do	do	Do.
Phebe	70	do	do	Do.
S. L. Goodale	70	do	do	Do.
H. M. Pirce	20	do	do	Do.
—— ——		J. S. Nickerson	Hodgdon's Mills, Me	Do.
—— ——		do	do	Do.
Job T. Wilson		Thomas Nichols	Round Pond, Me	Do.
Leonard Brightman		do	do	Do.
Emma		Pemaquid Oil Comp'y		Do.
—— ——		Tuthill, French & Co	South Bristol, Me	Do.
—— ——		do	do	Do.
—— ——		do	do	Do.
Hunter	90	Jonathan Bowrne, jr	New Bedford, Mass	Do.
George H. Bradley	53	do	do	Do.
Belle and Hattie	57	do	do	Do.
Nellie E. Rawson	56	do	do	Do.
Geo. W. Hunt	54	do	do	Do.
David H. Wilson		Job T. Wilson	Fall River, Mass	Do.
Chance-Shot	59	George Devoll	do	Do.
Lottie W. Merrill		W. J. Brightman	Tiverton, R. I	Do.
Paulina Wilbor		do	do	Do.
Fearless	70	do	do	Do.
Kingfisher		do	do	Do.
A. M. Hathaway		Joseph Church & Co	do	Do.
Joseph Church		do	do	Do.
Ospray		do	do	Do.
Jemima Boomer		do	do	Do.
Bessie Sims		do	do	Do.
George W. Humphrey		do	do	Do.
Seven Brothers		do	do	Do.
—— ——		Charles Cook	Tiverton Four Corners, R. I.	Do.
Grace		Isaac D. Manchester	Newport, R. I	Do.
E. T. De Blois	$81\frac{30}{100}$	E. T. De Blois	Portsmouth, R. I	Do.
Albert Brown	$78\frac{05}{100}$	do	do	Do.
Wm. A. Wells	$51\frac{68}{100}$	do	do	Do.
G. Polhemus		Gallup, Holmes & Co	Groton, Conn	Connecticut.
Aeronaut		do	do	Do.
H. T. Sisson		do	do	Do.
Gypsy Girl		do	do	Do.
Daisy	66	Gallup, Morgan & Co	do	Do.
Jno. A. Morgan	87	do	do	Do.
—— ——		Gallup & Manchester	do	Do.
—— ——		do	do	Do.
Luce Bros	76	Luce Bros	East Lyme, Conn	Do.
Emily Foote		Fowler & Foote	Guilford, Conn	Do.
—— ——		George W. Miles Co	Milford, Conn	Do.
—— ——		do	do	Do.
Wm. Spicer		Quinnipiac Fertilizer Company.	New London, Conn	Do.
Price		Frank Price	Greenport, N. Y	Long Island.
Newins		do	do	Do.
Lizzie		do	do	Do.
Colburn		do	do	Do.
Wm. Floyd	60	Hawkins Bros	Jamesport, N. Y	Do.
E. S. Havens	60	do	do	Do.
George T. Morse	$70\frac{1}{2}$	do	do	Do.
Oak			Greenport, N. Y	Do.
Cambria			do	Do.

Partial list of vessels employed in the menhaden fishery—Continued.

SAILING-VESSELS.

Name.	Tonnage.	Owner.	Port of entry.	Where fishing.
E. B. Church	40	W. J. Brightman	Tiverton, R. I	Maine.
Dragonet	30	do	do	Do.
Penikese	25	do	do	Do.
Willie E. Brightman	22	do	do	Do.
Long Island	11	do	do	Do.
Gracie	12	do	do	Do.
Sunbeam	12	do	do	Do.
Dora	9	do	do	Do.
D. T. Vail	32	Gurdon S. Allyn	Mystic, Conn	Connecticut.
Hadley	14	do	do	Do.
Hepsie	$18\frac{44}{100}$	do	do	Do.
Ramble	$14\frac{14}{100}$	do	do	Do.
Flash	$10\frac{56}{100}$	do	do	Do.
C. A. Sounds	$16\frac{82}{100}$	do	do	Do.
Annie	$19\frac{76}{100}$	do	do	Do.
J. W. Luce	22	Luce Bros	East Lyme, Conn	Do.
Success	22	do	do	Do.
Rustic	19	do	do	Do.
Flirt	19	do	do	Do.
Liza A. Luce	17	do	do	Do.
Nettie J. Luce	16	do	do	Do.
Nevada	17	do	do	Do.
Pacific	9	do	do	Do.
Haze	22	do	do	Do.
Col. Morgan		Greene Brothers	Greenport, N. Y	Long Island.
M. A. Greene		do	do	Do.
Allie		do	do	Do.
Phœnix		do	do	Do.
Elnora		do	do	Do.
Annat Pitcher		do	do	Do.
Mistonax		do	do	Do.
Swan	$24\frac{64}{100}$	Sterling Company	do	Do.
Mary H. Sisson	$20\frac{95}{100}$	do	do	Do.
Dauntless	$19\frac{70}{100}$	do	do	Do.
Bunker City	$8\frac{64}{100}$	do	do	Do.
Rough & Ready	$10\frac{24}{100}$	do	do	Do.
Sarah	$10\frac{37}{100}$	do	do	Do.
Kate Romer	$9\frac{83}{100}$	do	do	Do.
Friendly	$13\frac{37}{100}$	do	do	Do.
John Marcy	$12\frac{50}{100}$	do	do	Do.
Annie Homan	22	Wm. G. Fithian & Co	Napeague	Do.
Eureka	21	do	do	Do.
Wm. Downs	18	do	do	Do.
Jessie Smith	14	do	do	Do.
Native	14	do	do	Do.
G. P. Horton	14	do	do	Do.
Eliza Maria	14	do	do	Do.
	12	Hawkins Brothers	Jamesport, N. Y	Do.
	12	do	do	Do.
Peerless	22	do	do	Do.
Sirocco	22	do	do	Do.
Starlight	22	do	do	Do.
Simoon	12	do	do	Do.
Typhoon	12	do	do	Do.
Young America	12	do	do	Do.
Clyde	12	do	do	Do.
Geo. Nelson	12	do	do	Do.
Pelican	12	do	do	Do.
	12	do	do	Do.
Rob't Mills	10	Seaman Jones	Barren Island, N. Y	Do.
Golden Rule	15	do	do	Do.
Morning Light	15	do	do	Do.
N. M. Preston	15	do	do	Do.
McClane	15	do	do	Do.
Madeline	15	do	do	Do.
V. Koon	24	do	do	Do.
Rosa Belle	19	do	do	Do.
Lizzie Lane	19	do	do	Do.

APPENDIX K.

PRICES CURRENT OF MENHADEN OIL. 1871–1878.

Date.	Select light.	Choice brown.	Inferior to dark.	Gurry.	Strained.	Pressed.
	Cents per gallon.	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*
1871.						
October 18	41 to 42	39½ to 40½	35 to 38	20 to 25	....	....
October 25	41 to 41½	39½ to 40½	35 to 38	20 to 25	....	....
November 1	40½ to 41	39½ to 40	35 to 38	20 to 25	....	....
November 8	45 to 47½	42½ to 45	40 to 42½	25 to 30	....	....
November 15	50	47½ to 50	40 to 45	30 to 35	....	....
November 22	52	47½ to 50	45 to 47½	30 to 35	....	....
November 29	52½ to 55	50 to 52	47½ to 50	35 to 40	....	....
December 6	52½ to 55	50 to 52½	47½ to 50	35 to 40	60 to 62½	....
December 13	55	52½	47½ to 50	35 to 40	58 to 60	....
December 20	55	52½	47½ to 50	35 to 40	58 to 60	....
December 27	53 to 55	52½	47½ to 50	30 to 40	58 to 60	....
1872.						
January 3	55	52½	47½ to 50	30 to 40	58 to 65	....
January 10	55 to 57½	52½	47½ to 50	33 to 45	58 to 65	....
January 17	55 to 57½	52½	47½ to 50	35 to 45	58 to 65	....
January 24	55	52½	47½ to 50	35 to 45	60 to 65	....
January 31	55 to 56	52½	47½ to 50	35 to 45	60 to 65	....
February 7	55 to 56	52½	47½ to 50	35 to 45	60 to 65	....
February 14	55	52½	47½ to 50	35 to 45	....	60 to 65
February 21	55	52½	47½ to 50	35 to 45	....	60 to 65
February 28	54	52½	47½ to 50	35 to 45	....	60 to 65
March 6	53½ to 55	51 to 52½	46 to 48	35 to 45	....	60 to 62½
March 13	53 to 54	51 to 52	45 to 48	35 to 45	....	60
March 20	52 to 54	51	45 to 48	35 to 45	....	60 to 61
March 27	55 to 56	53 to 54	48 to 50	40 to 45	....	60 to 65
April 3	60	57½	....	40 to 45	....	60 to 65
April 10	62½	60	....	40 to 45	....	63 to 65
April 17	62½ to 65	60 to 62½	55 to 57½	45	....	64 to 66
April 24	62 to 64	60 to 62	55 to 57	45	....	64 to 66
May 1	60 to 62	60	55 to 57½	45	....	64 to 66
May 8	60	58 to 59	55 to 57	45	....	63 to 65
May 15	58 to 60	54 to 56	50 to 52½	45 to 47½	....	61 to 63
May 22	55 to 57½	50 to 52½	45 to 47½	....	....	60 to 63
May 29	48 to 50	45 to 47½	40 to 42½	....	....	60 to 61
June 5	47	43 to 44	40	....	....	52 to 55
June 12	40 to 42½	37 to 39	36 to 38	....	....	45 to 50
June 19	40 to 42½	37 to 39	36 to 38	....	....	45 to 50
June 26	41 to 42	40 to 41	37 to 39	....	....	45 to 47½
July 3	47 to 48	45 to 46	43 to 44	....	....	47 to 49
July 10	46 to 47	42½ to 44	40 to 42	....	....	47 to 49
July 17	44 to 45	42½ to 43	40 to 42	....	....	46 to 48
July 24	44 to 45	42½ to 43	40 to 42	....	....	47 to 50
July 31	47 to 48	45 to 46	40 to 42	....	....	48 to 50
August 7	44 to 45	43	40	....	....	....
August 14	44	43	38 to 40	25 to 30	....	....
August 21	44 to 45	43 to 44	40	25 to 30	....	....
August 28	43 to 44	42 to 43	40	25 to 30	....	....
September 4	43 to 44	42 to 43	40	25 to 30	....	....
September 11	44½ to 45	43 to 42	40	25 to 35	....	....
September 18	45 to 47	43 to 44	40 to 42	25 to 35	....	....
September 25	50 to 52	47 to 49	44 to 46	28 to 38	....	....
October 2	51 to 52	50	45 to 48	35 to 40	....	....
October 9	51	50	45 to 48	35 to 40	....	....
October 16	50	48 to 49	44 to 46	35 to 40	....	....
October 23	50 to 52½	48 to 49	44 to 46	35 to 40	....	....
October 30	50	48 to 49	44 to 46	35 to 40	....	....
November 6	50	48 to 49	44 to 46	35 to 40	....	....
November 13	50	48 to 49	44 to 46	35 to 40	....	....
November 20	54 to 55	50 to 52½	46 to 48	35 to 42	....	....
November 27	55	53 to 54	50 to 51	40 to 42	....	....
December 4	56	54 to 55	52 to 53	45 to 50	....	....
December 11	55	52½ to 55	48 to 50	45 to 47	....	....
December 18	55 to 56	52½ to 55	48 to 50	45 to 47	....	....
December 25	55 to 56	52½ to 55	48 to 50	45 to 47	....	....
1873.						
January 1	55 to 56	52½ to 55	48 to 50	45 to 47	....	55 to 57½
January 8	58	56 to 57	52 to 55	48 to 50	....	....
January 15	58	56 to 57	52 to 55	48 to 50	....	....

Prices current of menhaden oil—Continued.

Date.	Select light.	Choice brown.	Inferior to dark.	Gurry.	Strained.	Pressed.
	Cents per gallon.	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*
1873.						
January 22	58	56 to 57	52 to 55	48 to 50	....	....
January 29	58	57	55	50	....	....
February 5	58	57	55	50	....	....
February 12	60	59	58	....	....	....
February 19	60	59	58	....	....	....
February 26	60	59 to 60	....	....	....	....
March 5	60	59 to 60	....	....	....	....
March 12	60	59 to 60	....	....	....	....
March 19	60	59 to 60	....	....	....	....
March 26	60	59 to 60	....	....	....	....
April 2	60 to 62	60	....	....	....	....
April 9	60	60	....	....	....	....
April 16	60	58 to 60	....	....	....	....
April 23	60	58 to 60	....	....	....	....
April 30	57½ to 60	....	....	....	....	....
May 7	55½ to 60	....	....	....	....	....
May 14	55 to 57½	....	....	....	....	....
May 21	56	....	....	....	....	....
May 28	55 to 56	....	....	....	....	....
June 4	52½ to 55	50	....	....	....	....
June 11	52½ to 55	50	....	....	....	....
June 18	....	51	50	....	....	....
June 25	51	50	....	....	....	....
July 2	50	49 to 50	47½	....	....	....
July 9	50	49 to 50	47½	....	....	....
July 16	42½	40 to 42	37½	....	....	....
July 23	41	40 to 41	37½	....	....	....
July 30	40	39 to 40	37½	....	....	....
August 6	40	39 to 40	37½	....	....	....
August 13	40 to 41	39 to 40	37½	....	....	....
August 20	41¼ to 45	41 to 42	38 to 40	....	....	....
August 27	45	44 to 45	40 to 43	....	....	....
September 3	45	44 to 45	40 to 43	....	....	....
September 10	45	44 to 45	40 to 43	....	....	....
September 17	45	44 to 45	40 to 43	....	....	....
September 24	45	44 to 45	40 to 43	....	....	....
October 1	43 to 45	40 to 43	....	....	....	....
October 8	42 to 44	40 to 42	....	....	....	....
October 15	40 to 41	40	....	....	....	....

Date.	Select light.	Choice brown.	Inferior dark.	Select light, strained.
	Cents per gallon.	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*
1873.				
October 22	40 to 41	40	....	....
October 29	38 to 40	37½	....	....
November 5	37½	36 to 37	....	....
November 12	33 to 35	31 to 32	30	....
November 19	32½ to 35	30 to 32	29	....
November 26	33 to 35	33	30	....
December 3	38 to 40	37½	35	....
December 10	41	40	35	....
December 17	40 to 42½	40	35 to 37½	....
December 24	40 to 42½	40	35 to 37½	....
December 31	40 to 42½	40	35 to 37½	....
1874.				
January 7	40 to 42½	40	35 to 37½	....
January 14	....	....	....	....
January 21	45	45	40 to 42½	....
January 28	44 to 45	44	40 to 42½	....
February 4	45 to 47½	45	42½ to 43	....
February 11	45 to 47½	45 to 46	42½ to 45	....
February 18	47½	....	42½ to 45	....
February 25	45 to 47¼	....	42½ to 45	....
March 4	45 to 47½	....	42½ to 45	52½ to 55
March 11	45	....	42½ to 55	52½ to 55

Prices current of menhaden oil—Continued.

Date.	Select light.	Select light, strained.	Choice brown.	Inferior to dark.
	Cents per gallon.	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*
1874.				
March 18	42½ to 45	52½ to 55	....	40 to 42
March 25	43 to 45	52½ to 55	....	40 to 42
April 1	43 to 45	52½ to 55	42 to 43	40 to 42
April 8	41 to 42	52½ to 55	40 to 41	38 to 40
April 15	41 to 42	50	41	....
April 22	41 to 42	50	41	....
April 29	41 to 42	50	41	....
May 6	40 to 42	48 to 50	....	....
May 13	40 to 42	48 to 50	....	....
May 20	40 to 41	46 to 47	....	....
May 27	40 to 41	46 to 47	....	....
June 3	40	46	....	....
June 10	37 to 39	44 to 45	....	....
June 17	37 to 39	44 to 45	....	....
June 24	35 to 37	42 to 43	35	32 to 34
July 1	....	....	....	....
July 8	37 to 39	43 to 45	37	34 to 36
July 15	36 to 37	42 to 43	36	34 to 36
July 22	35 to 36	41 to 42	35	32 to 34
July 29	36	41 to 42	35	32 to 34
August 5	36	40 to 42	35 to 35½	32 to 34
August 12	36	40 to 42	35 to 35½	32 to 34
August 19	36	40 to 42	35 to 35½	32 to 34
August 26	36	40 to 42	35 to 35½	32 to 34
September 2	36	40 to 42	35 to 35½	32 to 34
September 9	36 to 37	40 to 42	35 to 35½	32 to 34
September 16	36 to 37	40 to 42	35 to 35½	32 to 34
September 23	36 to 37	40 to 42	35 to 35½	32 to 34
September 30	36 to 38	40 to 42	35 to 36	32 to 34
October 7	36 to 38	40 to 42	35 to 36	32 to 34
October 14	39 to 40	44	37 to 38	35 to 36
October 21	40 to 42	46 to 48	38 to 39	36 to 38
October 28	42 to 43	48 to 50	40 to 42	38 to 40
November 4	42 to 43	48 to 50	41 to 42	38 to 40
November 11	41 to 42	47 to 49	40 to 41	38 to 39
November 18	40 to 41	45 to 46	36 to 40	37 to 39
November 25	40 to 41	45 to 46	36 to 40	37 to 39
December 2	40 to 41	45 to 46	39 to 40	37 to 39
December 9	40 to 41	45 to 46	39 to 40	37 to 39
December 16	40 to 41	45 to 46	39 to 40	37 to 39
December 23	40	45 to 46	38 to 40	35 to 36
December 30	38 to 40	45 to 46	38	35 to 36
1875.				
January 6	38 to 40	45 to 46	38	35 to 36
January 13	38 to 40	44 to 46	38 to 40	35 to 36
January 20	40	44 to 46	40	36 to 38
January 27	40 to 42	44 to 46	40	36 to 38
February 3	40 to 42	44 to 46	40	36 to 38
February 10	42	44 to 46	41	36 to 38
February 17	42	44 to 46	41	36 to 38
February 24	43 to 44	45 to 46	43	36 to 38
March 3	43 to 44	45 to 46	42 to 43	36 to 38
March 10	42 to 43	45 to 46	42	36 to 38
March 17	41 to 42	45 to 46	40 to 41	36 to 38
March 24	41 to 42	45 to 46	40	36 to 38
March 31	41	45 to 46	40	36 to 38
April 7	41	45 to 46	40	36 to 38
April 14	41	45 to 46	40	36 to 38
April 21	41 to 42	45 to 46	40	36 to 38
April 28	44 to 46	....	41 to 42	38 to 40
May 5	45 to 46	49 to 50	42 to 43	38 to 40
May 12	44 to 45	49 to 50	41 to 42	38 to 40
May 19	42 to 44	49 to 50	41 to 42	25 to 40
May 26	40 to 41	49 to 50	39 to 40	25 to 30
June 2	40	47 to 48	37 to 38	25 to 30

Prices current of menhaden oil—Continued.

Date.	Select light.	Select light, strained.	Bleached.	Choice brown.	Inferior to dark.
	Cents per gallon.	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*
1875.					
June 9	38 to 39	44 to 45	50	37 to 38	25 to 30
June 16	38 to 39	44 to 45	50	37 to 38	25 to 35
June 23	38 to 39	44 to 45	50	37 to 38	25 to 35
June 30	36 to 37	44 to 45	50	35 to 36	25 to 33
July 7	36 to 37	44 to 45	49 to 50	35	25 to 33
July 14	35 to 36	44 to 45	49 to 50	35	25 to 33
July 21	35 to 36	44 to 45	49 to 50	35	25 to 33
July 28	35 to 36	42 to 44	47½ to 48	34½ to 35	25 to 34
August 4	34½ to 35	40 to 41	45 to 46	33 to 34	25 to 33
August 11	33	38 to 40	44 to 46	33	25 to 30
August 18	32 to 33	38 to 40	44 to 46	32	25 to 31
August 25	32 to 32½	38 to 40	44 to 46	32	25 to 31
September 1	32	38	44 to 45	31	25 to 30
September 8	32	38	44 to 45	31	25 to 30
September 15	32 to 33	38	44 to 45	31 to 32	20 to 30
September 22	32 to 33	38	44 to 45	32	20 to 30
September 29	33	38	44 to 46	32 to 33	20 to 30
October 6	34 to 35	38	44 to 46	32 to 33	20 to 30
October 13	34 to 35	38	44 to 46	32 to 33	20 to 30
October 20	36	40 to 42	50	34 to 36	....
October 27	40 to 41	44 to 45	52 to 54	40	....
November 3	40 to 41	44 to 45	52½ to 54	40	....
November 10	40 to 41	44 to 45	52½ to 55	40	....
November 17	40 to 41	44 to 45	52½ to 55	40	....
November 24	41 to 42	46 to 48	52½ to 55	40 to 41	....
December 1	42 to 44	46 to 48	52½ to 55	41 to 42	....
December 8	42 to 44	46 to 48	52½ to 55	41 to 42	....
December 15	44 to 45	48	54 to 55	42 to 43	....
December 22	45 to 47½	46 to 48	55 to 56	43 to 44	....
December 29	45 to 47½	46 to 48	55 to 56	43 to 44	....
1876.					
January 5	47½ to 50	48 to 50	55 to 56	45 to 47½	....
January 12	47½ to 50	50 to 52	55 to 60	45 to 47½	....
January 19	47½ to 50	50 to 52	55 to 60	45 to 47½	....
January 26	47½ to 50	50 to 52	55 to 60	45 to 47½	....
February 2	47½ to 50	50 to 52	55 to 60	45 to 47½	....
February 9	47½ to 50	50 to 52	55 to 60	45 to 47½	....
February 16	48 to 50	50 to 52	55 to 58	45 to 47½	....
February 23	48 to 50	50 to 52	55 to 58	45 to 47½	....
March 1	48 to 50	50 to 52	55 to 58	45 to 47	....
March 8	....	....	....	....	....
March 15	47 to 48	50 to 52½	55 to 56	45 to 46	....
March 22	45 to 48	50 to 52½	55 to 56	45 to 46	....
March 29	45 to 48	50 to 52½	55 to 56	45 to 46	....
April 5	45 to 48	50 to 52½	55 to 56	45 to 46	....
April 12	45 to 47	50 to 52½	52 to 55	44 to 46	....
April 19	45	48 to 50	52 to 53	44	....
April 26	45	48 to 50	52 to 53	44	....
May 3	45	48 to 50	52 to 53	44	....
May 10	45	48 to 50	52 to 53	44	....
May 17	35	42 to 44	46 to 50	46 to 48	....
May 24	35	40 to 41	45 to 47½	34 to 35	....
May 31	35 to 36	40 to 41	45 to 47½	34 to 35	....
June 7	35 to 36	40 to 41	45 to 47½	34 to 35	....
June 14	36 to 37	42 to 44	45 to 47½	35	....
June 21	38 to 39	44 to 46	45 to 47½	37 to 38	....
June 28	35 to 38	44 to 46	45 to 47½	35 to 36	....
July 5	35 to 38	44 to 46	45 to 47½	35 to 36	....
July 12	36 to 38	44 to 46	45 to 47½	35 to 36	....
July 19	35 to 35½	....	46 to 50	34 to 35	....
July 26	33½ to 34	....	46 to 50	32½ to 33	....
August 2	32½ to 33	....	46 to 50	32	....
August 9	33	....	46 to 50	32	....
August 16	33	....	45 to 47	32	....
August 23	33	....	45	32	....
August 30	33 to 34	40	45	33	....
September 6	34 to 35	40	45	33	....
September 13	34 to 35	40	45	33	....
September 20	34 to 35	40	45	33	....
September 27	34 to 35	40	45	33	....
October 4	35	40	45	33 to 34	....
October 11	38 to 30	44	47	36 to 37	35
October 18	42 to 45	46 to 48	48 to 50	38 to 40	35 to 36

Prices current of menhaden oil—Continued.

Date.	Select light.	Select light, strained.	Bleached.	Choice brown.	Inferior to dark.
	Cents per gallon.	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*	*Cents per gallon.*
1876.					
October 25	42 to 45	46 to 48	48 to 50	38 to 40	35 to 36
November 1	42 to 43	45 to 46	48 to 50	40	36
November 8	40 to 42	45 to 46	48 to 50	38 to 40	36
November 15	40 to 42	45 to 46	50 to 52	38 to 40	36
November 22	40 to 42	45 to 46	50 to 52	38 to 40	36
November 29	40 to 42	45 to 46	50 to 52	38 to 40	36
December 6	40 to 42	45 to 46	50 to 52	38 to 40	34 to 36
December 13	41 to 42	45 to 46	50 to 52	40	34 to 36
December 20	41 to 42	45 to 46	50 to 52	40	34 to 36
December 27	41 to 42	45 to 46	50 to 52	40	34 to 36
1877.					
January 3	41 to 42	45 to 46	50 to 52	40	34 to 36
January 10	42 to 43	45 to 46	50 to 52	40	34 to 36
January 17	42 to 45	46 to 48	52	40	34 to 36
January 24	42 to 45	46 to 48	52	40	34 to 36
January 31	41 to 45	46 to 48	52	40	34 to 36
February 7	42 to 45	46 to 48	52	40	34 to 36
February 14	40 to 43	45 to 46	52	40 to 41	34 to 36
February 21	40 to 42½	44 to 45	50 to 52	40 to 41	34 to 36
February 28	40 to 42½	41½ to 45	50 to 52	40 to 41	34 to 36
March 7	41 to 42	42½ to 44	48 to 50	40	34 to 36
March 14	41 to 42	42 to 43	47 to 49	38 to 39	34 to 35
March 21	41 to 42	42 to 43	47 to 49	38 to 39	34 to 35
March 28	41 to 42	42 to 43	47 to 49	38 to 39	34 to 35
April 4	40 to 41	42 to 43	47 to 48	38 to 39	34 to 35
April 11	40 to 41	42 to 43	47 to 48	38 to 39	34 to 35
April 18	37½ to 40	42 to 43	45 to 47½	35 to 36	32 to 34
April 25	36 to 38	41 to 42	42½ to 45	33 to 34	30 to 32
May 2	38	42	43 to 46	34 to 36	30 to 32
May 9	38	42	43 to 46	36 to 37	32 to 34
May 16	38	42	45 to 46	36 to 37	32 to 34
May 23	37½	42	45 to 46	36 to 37	32 to 34
May 30	36½ to 37½	42	45 to 46	36	32 to 34
June 6	34 to 35	42	45 to 46	34	32 to 34
June 13	34 to 35	42	45 to 46	34	32 to 34
June 20	34 to 35	38 to 40	45 to 46	34	32 to 34
June 27	34 to 35	38 to 40	45 to 46	34	32 to 34
July 4	33 to 34	38 to 40	45 to 46	32½	30 to 32
July 11	33 to 34	38 to 40	45 to 46	32½	30 to 32
July 18	33 to 34	38 to 40	45 to 46	32½	30 to 32
July 25	33 to 34	38 to 40	45 to 46	32½	30 to 32
August 1	33 to 34	38 to 40	45 to 46	32½	30 to 32
August 8	34	38 to 40	45 to 46	33½	30 to 32
August 15	36½	38 to 40	45 to 46	36 to 35	34 to 35
August 22	36½	38 to 40	45 to 46	35 to 36	34 to 35
August 29	38	40 to 42	47 to 48	35 to 36	34 to 35
September 5	38	40 to 42	47 to 48	35 to 36	34 to 35
September 12	42 to 45	44 to 46	49 to 50	38 to 40	35 to 38
September 19	45	44 to 46	50 to 52	42 to 44	40 to 42
September 26	45	46 to 47	51 to 52	42 to 44	40 to 42
October 3	45	46 to 47	52 to 53	44	40 to 42
October 10	45	46 to 47	52 to 53	44	40 to 42
October 17	45	46 to 47	52 to 53	44	40 to 42
October 24	45 to 46	47 to 48	52 to 53	44	40 to 42
October 31	45 to 46	47 to 48	52 to 53	44	40 to 42
November 7	45 to 46	47 to 48	52 to 53	44	40 to 42
November 14	45	47 to 48	52 to 54	44	40 to 42
November 21	45	47 to 48	52 to 54	44 to 44½	40 to 42
November 28	45	47 to 48	52 to 54	44 to 44½	40 to 42
December 5	45	47 to 48	53 to 54	44 to 44½	40 to 42
December 12	46	48 to 50	53 to 54	45 to 45½	40 to 42
December 19	46 to 47	48 to 50	52½ to 53½	45 to 46	40 to 42
December 26	46 to 47	48 to 50	52½ to 53½	45 to 46	40 to 42
1878.					
January 2	46 to 47	48 to 50	52½ to 53½	45 to 46	40 to 42

CURRENT WEEKLY REPORTS OF THE MENHADEN OIL MARKET FROM 1871-1878.

[Compiled from "Oil, Paint, and Drug Reporter," of New York, W. O. Allison, editor.]

1871.

OCTOBER 18.

Menhaden with many small lots arriving during the latter part of last week reacted from the advanced prices, and some sales were made at a decline of fully 1c. per gallon; the close is, we think, rather more steady, with most of the arrivals bought up. Sales are 68 bbls. prime white, at 41½c.; 112 bbls., at 41c.; 90 bbls., at 40½c.; 110 bbls., at 40c.; 61 bbls. light, at 41c.; 125 bbls., on p. t.; 150 bbls. fair, at 39c.; 50 prime, at 40½c.; 12 bbls. common, at 30c.; 30 bbls. Gurry, at 20 @ 25c.; and 50 bbls. re-pressed choice, at 45 @ 48c.; also 7,000 lbs. foots for export, at 4½c., and 300 tons of guano, at $15, delivered.

OCTOBER 25, 1871.

Menhaden has been scarce all the week; there has been a demand for more than could be obtained; 250 bbls. sold at the close for export at 41c., and in lots, 300 bbls. for home use, at 41 @ 41½c. for choice light, and 39 @ 40c. for choice brown.

NOVEMBER 1.

Menhaden has been in rather light demand, and with free receipts of choice new fall made prices lower at the close, with several lots offering on the market. The sales are 280 bbls. on private terms; 50 bbls. selected light last week at 42c.; 101 bbls. choice, at 40½c.; 98 do. at 40½c.; 25 bbls. brown, at 39½c.; and a mixed lot of 30 bbls., at 39c.

NOVEMBER 8.

Menhaden has been in steady, fair demand during the past week, and the close is very much higher and somewhat unsettled; 45c. is bid choice. The sales during the past week are as follows: 378 bbls. prime, at 40c.; 150 bbls. good, at 39½c.; 200 bbls. choice, at 40½c.; 100 bbls. to arrive, at 41c.; 150 bbls. at the factory, at 40c.; 75 bbls. for export, at 41c.; 200 bbls., at 41½c.; and 113 bbls., at 40½c.; and 250 bbls. pressed on private terms.

NOVEMBER 15.

Menhaden has been fairly active and more excited than any other kind on our list; prices have advanced, and at the close the tendency is apparently upward, though we hear of one lot of choice offered for sale at 50c. Sales are 150 bbls., at 47½c.; 100 bbls., at 50c.; 190 bbls., at 50c.; 25 bbls. on private terms, and 131 bbls. on private terms.

NOVEMBER 22.

Menhaden has continued to move freely, and prices have still further advanced. If a party wants to buy, 52½c. is the lowest price for a good lot. At the close 100 bbls. on dock were offered at this price, without a

buyer, and will be put in store—50c. was bid. All the sales, however, of prime lots made this week have been at this price. We notice sales of 25 bbls. inferior at 47½c.; 200 bbls. last week, at 50c. or less; 60 bbls. choice, at 52½c.; 100 bbls., at 52½c.; 120 bbls., at 52½c.; 50 bbls. choice, at 52½c., and 100 bbls., at 52½c. Pressed menhaden meets with a good demand; 50 bbls. sold at 60c. Jobbing lots can be sold easily at this price.

NOVEMBER 29.

Menhaden has been more active and rules very strong; at the close 52½c. has been refused, but we hear of no lots from first hands having brought more. The sales of crude are 185 bbls, at 52½c.; 200 bbls., at 52c.; 38 bbls., 27 bbls., 22 bbls., and 25 bbls., at 52½c.; also, 25 bbls. at higher price, not given. Pressed is generally quoted at 60c., though some parties are still offering for less.

DECEMBER 6.

Menhaden has ruled quiet the past week. We know of no actual sale from first hands at more than 52½c., though an outside party is said to have paid 53c.; some of the largest holders are not offering their stock at the present. The sales are in all 250 bbls. on spot at 52½c. and 114 bbls. to arrive at same price. Pressed is held higher, though some parties who had some before the advance are underselling the regular trade.

DECEMBER 13.

Menhaden is very firm. There are few parties willing to sell at less than 55c. A sale was rumored to-day at 54c., but we know of no parties willing to pay more than 52½c.; 100 bbls. sold here at this price, and in Boston 10,000 gallons, for export, at 52½c., and 100 bbls. for home use, at 53½c.

DECEMBER 20.

Menhaden has been very quiet during the past week; dealers are taking all lots that are offering cheap, and prices remain steady, though no full lots of choice have reached our highest quotations. The only sales we hear of are 120 bbls. at 52½ @ 53c., and 77 bbls. on private terms below the market.

DECEMBER 27.

Menhaden has been very quiet; those who hold stock look for full prices, but buyers will not pay the advance for full lots. We hear of no sales. There is a report that some of the menhaden exported is on the way to this market again. We were informed by a party having a large lot in the English market that if it did not improve in price there, he would have his shipped back to this market again; if the oil is on shipboard, this can be done at a small profit, taking the markets as they are quoted at present.

1872.

JANUARY 3.

Menhaden has improved in tone again; buyers have been forced to pay the prices demanded by holders, and the tendency is again upward.

We hear of a sale of 108 bbls. prime light at 55c., and 50 bbls. not sweet at 52½c. There is a good demand for pressed, and the choicest is held at higher prices, with full sales. We note 75 bbls. sold at 65c., 20 bbls. brown at 60c., and a small lot at 58c.

JANUARY 10.

Menhaden oil meets with very little demand; the ideas of holders are above those of buyers, and we have no business to report; there are rumors but no actual sales of full lots that we can learn of. The demand for pressed fish is fair; 25 bbls. brown sold at 60c., and 25 bbls. light at 63c.

JANUARY 17.

Menhaden rules quiet; to sell freely lower prices would have to be accepted, but to buy full prices would have to be paid. No sales of lots are reported.

JANUARY 24.

Menhaden rules about steady, though if forced on the market would not command the highest quotation. The feeling is, however, that the stock is small and all will be needed. We hear of the sale of 50 bbls. prime, at 55c., and 112 bbls. Southern, part dark, at 52c. cash. There is a fair demand for strained and 25 bbls. are reported sold at 63c.

JANUARY 13.

Menhaden is steady in prices, the only large lot held, 600 bbls., was at New Bedford, which has been sold to a manufacturer there at a price equal to 55c., delivered in this city, the lot of Southern reported in our last has been rejected; at the close to-day we hear of the sale of 120 bbls. on private terms. Strained sells in a small way, if choice, at 65c., in full lots at 60 @ 62½c., and brown 60c. in a small way.

FEBRUARY 7.

Menhaden is held confidently, but there is not much doing. We hear of no full lots having changed hands.

FEBRUARY 14.

Menhaden is quiet and there are no sales making; we have only heard during the past week of a few lots, perhaps in all 50 bbls., that changed hands at 55c. The stock is pretty firmly held by a few parties. Pressed oil is in fair demand and firm.

FEBRUARY 21.

Menhaden is dull to buy; the market is firm, but to sell it is weak, though at a decline of 2½ @ 5c. the whole market might be cleared of stock; no sale of lots for a week.

FEBRUARY 28.

Menhaden has ruled quiet during the past week, and as there have been no sales for some time past, the feeling has been hardly so firm; 100 bbls. choice sold at 54c., the other kinds have met with no sales since our last.

MARCH 6.

Menhaden has been quiet for a long time past, and holders appear more anxious to sell. We hear that sales have been made of 300 bbls. prime, on private terms, though understood to be below 54c.

MARCH 13.

Menhaden has been quiet; the dealers are doing very little, and will not buy unless at a decline from former prices. The sales are 120 bbls. light at 53c. We note the arrival of the first lot of the oil returned from the other side, some 8,000 galls; there are about 42,000 galls. more on the way. Pressed fish oil meets with a slow sale.

MARCH 20.

Menhaden has moved a little more freely, but the sellers have been forced to accept lower prices; the close is, however, considered more firm, as the Boston combination may have some effect on this market. The only sale we hear of is a lot of 150 bbls. prime, at 52c. cash. There is a little better demand for pressed, and we note 30 bbls. sold at 60½c., and 50 bbls. at 60c.

MARCH 27.

Menhaden has been bought quite largely during the past week, which has had the effect of advancing prices; the sales are about 550 bbls., at 54 @ 55c., the latter for choice light, though at the close the highest price is said to have been bid for brown. Pressed meets with a fair sale; 2,500 gallons sold at 59 @ 61c., the lowest price for inferior, and 1,500 gallons choice winter at 64c.

APRIL 3.

Menhaden oil remains firm, and 58c. would be low for nice oil; some lots might be obtained at 55c., but it would be off in color. The combination is having some effect, and how long it will last is more than can be predicted.

APRIL 10.

Menhaden is scarce; there was too much shipped, which has left the market bare. Handsome is held at 60c.

APRIL 17.

Menhaden is firmer, and with the failure of the seal-fishery all grades of fish-oil will be in demand at advanced rates; 60c. for clean, handsome parcels might be obtained, and some ask an advance on this price.

APRIL 24.

Menhaden is quiet but firm; the principal holder asks 65c., but some others are quoting 62c. There have been no sales, but in New Bedford 400 bbls. sold to go to Boston, at 60c.

MAY 1.

Menhaden remains scarce & firm, 60 @ 62c. for handsome. There was too much shipped.

MAY 8.

Menhaden, as reported at the date of our last, is weak. We reported the market "less buoyant" last week and quoted choice at 60 @ 62c. in

our prices current. We have been accused "bearing" the market on that occasion, but we think our accuser could not have been posted, for the very choicest lots in market were offered the day of our issue at 60c., and not being able to get that price, asked for a bid of 59c. We have heard of no sales.

MAY 15.

Menhaden is quiet, and the feeling is easy; holders do not force sales, but are open for offers; buyers are generally very backward. The sales reported are 150 bbls. in New Bedford, and 40 bbls. here at 60c., though other choice lots are offered freely at this price. There have been sales of pressed at 62c.

MAY 22.

Menhaden is unsettled and lower. No one quotes higher than 57½c., and no one will bid 55c. There is considerable offering. We hear of no sales of lots since our last.

MAY 29.

Menhaden oil of the new catch is arriving more freely, and prices are lower at the close, with buyers holding off. There have been sales of 150 bbls. new at about 50c., but at the close we do not think that more than 47½c. could be obtained; thus far the oil we have seen is of very good quality, and not inferior, as some parties anticipated it would be.

JUNE 5.

Menhaden oil is lower; the receipts are quite free, and the tendency of prices have been steadily downward; the quality coming to this market has been very good for the first part of the season. The sales are 50 bbls. at 47c.; 43 bbls. at 45c., prompt cash; 60 bbls. at 45c.; 45 bbls. at 44½c., and 50 bbls. at 44c., at which the market closes not very strong; inferior was offered and refused at 40c.

JUNE 12.

Menhaden oil; nothing has been done in Maine as yet.

JUNE 19.

Menhaden, following our last, was in active request for Boston account, and, to some extent, for shipment, which took about all the surplus offerings and checked the downward tendency, and a firm tone now prevails. The fishermen are holding back as much as possible, and toward the close the run of fish is falling off. They also say that at 40c. per gallon, delivered in this market, there is no margin for making oil. The sales are 200 bbls. at 38c.; 600 bbls. at 39 @ 40c.; 200 bbls. at 40c.; 48 bbls. at 40 @ 40½c., and 75 bbls. taken to account at 40c.

JUNE 26.

Menhaden has been less plenty this week than last, and receivers have been able to get an advance on prime lots of 1 cent per gallon, and the close is steady at 41 cents. From Maine we hear that fish are very scarce, and that the Boston trade are likely to draw on this market for their supply for some time yet; besides, the fishermen, we believe, entered last fall into an arrangement not to sell below 60c. till the 15th of July.

JULY 3.

Menhaden has suddenly become scarce, and with some dealers short; the price has advanced as rapidly again as it declined. At the close we hear of one lot, about 45 bbls. light, offering, on which 47c. is said to have been bid and refused; the holder asks 48c. If any lots should be offered, this price could not be obtained, as shippers cannot pay more than 41c. We learn from Maine that the fish are more abundant, but do not yield largely.

JULY 10.

The market for menhaden has ruled quite irregular since our last; the arrivals at the close, however, are more free and prices are lower, but more uniform. There have been some lots taken for shipment, and the low prices ruling a short time ago will hardly again be reached. The sales are 142 bbls. prime at 43c.; 200 bbls. at 41½c.; and 450 bbls., part for shipment, on private terms, though some at considerably above the prices obtained for the above lots. There is a fair trade for pressed at 48c.

JULY 17.

The market for menhaden at the close is firm, owing to light arrivals this week. The trade talk a small catch, and say prices will probably rule higher. Last week there were sales of 200 bbls. at 43½c. for prime and 42c. for inferior, and 70 bbls. prime light at 44 @ 45c. The demand for strained is fair.

JULY 24.

Menhaden has been in rather moderate supply during the past week, and prices rule firm. At the close the advices from the fishermen are that they are catching more fish, and the yield is good. We note sales of 65 bbls. choice light at 43 c., and 50 bbls. brown at 40c.

JULY 31.

There has been more activity in menhaden than any other kind of oil on our list. The amount coming forward is small, and barely enough to supply the wants of the trade, causing prices again to advance. Heretofore the yield of the fish has been very small, but at the close to-day we hear that the run has suddenly become fat, and above an ordinary yield is now obtained. The sales are 104 bbls. choice brown at 46c.; 50 bbls. do. at 46c.; 40 bbls. racked at 46c.; 20 bbls. gurry at 25c.; 25 bbls. strictly winter pressed at 55c.; and a rumor, which, however, was not confirmed, of a lot of choice crude at 47c.

AUGUST 7.

Menhaden this week has been in better supply, and is quoted very much lower at the close. The catch is better and the yield fair for this season of the year; receipts since our last have been about 200 bbls., which sold at from 43c. for nice brown to 46c. for choice light; at the close we hear that a lot of 400 bbls. prime brown was offered, to arrive, at 43c.

AUGUST 14.

The market for menhaden has been quiet, and with dealers less anxious to buy; the close is easy at about 43c. for light brown. The high prices for freights will not allow of any shipping business at present ruling quotations. The sales reported for the week are 417 bbls. at 43 @ 44c., including a resale of 75 bbls. at the outside price; 200 bbls. to arrive at 42c., and a lot of 250 bbls. choice light in New Bedford some time since, not before reported, at 45c.

AUGUST 21.

Menhaden at the moment is scarce; there are orders here at 43c., but there is no stock to fill them; considerable lots are reported on the way, and this keeps prices from advancing materially, though we may quote at least 1c. better as the outside price.

AUGUST 28.

Menhaden oil remains as last reported. Prices are above views of buyers, but the manufacturers will not yield, and the result is that the oil will pass into parties' hands that will make advances on the oil. This locks the oil for the present.

SEPTEMBER 4.

Menhaden has not been plenty since our last, and a rather firmer tone is reported at the close. We hear of the arrival of a lot of 275 bbls. and of about 750 bbls. more on the way. The sales are 400 bbls., part to arrive, at 44c. for choice light, and 75 bbls., at 43c. for brown, and 40c. for inferior. The fishermen report a fair catch, and we hear that the yield is increasing both here and in Maine.

SEPTEMBER 11.

Menhaden is firm at the close, with moderate offerings. Last week the receipts were full, but were readily taken at steady prices. This week there have been no arrivals, and the tone firmer; probably 45c. could be obtained for a choice lot The sales reported since our last are 300 bbls., at 44c.; 75 bbls., at 44c.; 168 bbls., at 43½ @ 44c.; 90 choice and 70 do., at 44½c.

SEPTEMBER 18.

Menhaden rules firm, with a small amount arriving; sales 250 bbls. fair brown, at 44c.; 115 bbls. on private terms; 36 bbls. choice light, at 47c., and 100 choice tanked, at 48c.; also a rumor of 1,000 in New Bedford, at 50c.

SEPTEMBER 25.

Menhaden has advanced since our last about 4c. per gallon, owing to the small supply offering on the market. Sales have been made of 150 bbls., at 49 @ 50c. for light brown and choice; 38 bbls. brown, at 49c.; 30 bbls. and 50 bbls., at 50c., at which the market closes strong, with exporters willing to pay this price.

OCTOBER 2.

Menhaden oil has not arrived freely, and the price is rather stronger. Since our last, sales have been made of 150 bbls., at 50c., and to-day a

cargo arrived, and about 350 bbls. sold, at 50c., as it run, and a lot of 39 bbls. brown, at 50c., which is the price for any kind of good oil.

OCTOBER 9.

Menhaden has been quite active, and rules very firm; sales are 80 bbls. prime at 50c.; 82 bbls. at 52c.; 170 bbls. at 50½c.; 150 bbls., to arrive, at 50 @ 50½c.; and 425 bbls. on private terms. Most of the above lots were very choice light oils.

OCTOBER 16.

Menhaden has not come in so freely, still there is rather more offering, and buyers are holding off, and some report the market lower. There is some Maine offering, but we know of 48c. having been refused for it. We only note the sales during the week of 100 bbls. prime light at 50c., and 150 bbls. fair brown at 45c. The fall catch is reported better.

OCTOBER 23.

Menhaden rules steady for light oil, and all that has come forward has been taken at 50c.; we note sales of 159 bbls. at this price; 100 bbls. Maine oil at 52½c.; 100 bbls. do. at 53½c.; 100 bbls. pressed at 55c., and 30 bbls. do. at 57c.

OCTOBER 30.

Menhaden is a little easier, though in good demand; sales are 189 bbls. prime at 49c.; 150 bbls. at 49c.; 100 bbls. at 50c., thirty days; 100 bbls. at 50c., cash; and 55 bbls. at 50c. cash.

NOVEMBER 6.

Menhaden has ruled quiet but firm, with but few lots arriving. The only sales since our last are 100 bbls. at 50c. and 90 bbls at 49c.

NOVEMBER 13.

Menhaden is not arriving freely, and the market is very strong, with all the good oil that is offered taken at 49c., though most holders ask 50c. Sales are 278 bbls. at 49c.

NOVEMBER 20.

Menhaden is higher, with sales at an advance; the market is, however, somewhat unsettled. The stock in Boston, about 8,000 bbls., was burnt. Sales 280 bbls. and 100 bbls. on p. t., and last week 75 bbls. at 50½c.

NOVEMBER 27.

Menhaden oil has been actively dealt in, closing firm at an advance. The sales and resales have been fully 2,000 bbls. from 51c. up to 55c., which latter price is said to have been bid at the close for light oil and refused.

DECEMBER 4.

Menhaden has continued firm and is quiet. The stock is now pretty well out of first hands. Sales of 140 bbls. at 44c., and 600 bbls. at 55c.

DECEMBER 11.

Menhaden is quiet and a little unsettled; the supply in first hands very light, but jobbers report trade very dull, and a full supply on hand.

DECEMBER 18.

Menhaden has been quiet, owing to small offerings; sales are 30 bbls. prime light at 56c., and 70 bbls. on private terms.

DECEMBER 25.

Menhaden quiet but steady, with a small supply.

1873.

JANUARY 1.

Menhaden quiet, with only small sales making.

JANUARY 8.

Menhaden is firmer, and other oils used by tanners have also advanced.

JANUARY 15.

Menhaden oil rules quiet, and with a small stock very firm in price. We note sales of 120 bbls. from store, reported at 56c.

JANUARY 22.

Menhaden is quiet but very firm; no sales making.

JANUARY 29.

"Menhaden oil: some sales have been made at 57 to 58." (Boston oil-market reports.)

FEBRUARY 5.

Menhaden rules firm, though somewhat nominal, owing to the very small stock.

FEBRUARY 12.

Menhaden oil was active last week, and sales were made of 1,750 bbls. Maine oil, all reported at 60c.

FEBRUARY 19.

Menhaden oil is in small supply in first hands, but dealers hold a pretty fair stock.

FEBRUARY 26.

Menhaden is held very firmly, as there is a very small stock here. Brown oil will bring about as much as light, owing to the small supply.

MARCH 5.

Menhaden is firm, but very quiet; no sales reported.

MARCH 12.

Menhaden is firm, but not active; 100 bbls. Maine oil sold at 60c.

MARCH 19.

Menhaden oil rules quiet; there are some lots offering, to arrive, at 60c., for Maine catch.

MARCH 26.

Menhaden oil has ruled dull since our last offering at 60c. for Maine oil.

APRIL 2.

Menhaden oil rules quiet, but is held higher; no sales making.

APRIL 9.

Menhaden oil rules dull, and lots are pressing for sale; 60c. is asked, but a full lot could not be placed except at a much lower price; we have not a single transaction to note.

APRIL 16.

Menhaden is held at 60c., and not offered at less; but buyers would not buy any lots at anywhere near this price.

APRIL 23.

Menhaden oil nominal; no sales making.

APRIL 30.

Menhaden oil is easier, offering at 57½c. in lots for Maine catch. Sales are 300 bbls.; closing sale at this price.

MAY 7.

Menhaden oil is lower owing to the near approach of the fishing season, and sales have been made of 155 bbls., at 55c.; 25 bbls., at 56c.; and in Boston, 30 bbls., at 56c., and 80 bbls., at 57c.

MAY 14.

Menhaden oil is somewhat nominal, about all in the market having gone into second hands. Jobbers are said to have a smaller supply than usual at this season of the year, and the feeling may be considered a little stronger at the close, owing to the backwardness of the catch. There has been one small lot of inferior now in market from Florida, which has been sold at 50c. The Long Island fishermen report fish scarce and yielding only about one gallon per thousand. If the weather continues fine a few small lots may be expected next week, but not in sufficient quantities to supply the demand for some time. The prospect as to future prices is that the market, without any disturbing influences and a usual catch, will rule at about 42½c. The sales reported since our last are 500 bbls. prime Maine, at 55c., 50 bbls. ordinary, at 57c., and 11 bbls. inferior new Southern, at 50c.

MAY 21.

Menhaden oil has been in fair demand; it is said that the dealers have a small stock on hand. New oil has not yet arrived, but is daily expected. We note sales of 204 bbls. ordinary, at 55c., and 30 bbls. select, at 56c. From Boston reports we have:

"Menhaden oil remains quiet. Sales have been made at 55 and some lots of dark oil have sold at 50. As the season is approaching when new oil will soon make its appearance, those holding old oil are anxious to dispose of their stocks, and under such circumstances sales have been made below market value."

MAY 28.

Menhaden oil rules firm and in small supply. There is said to be no oil in first hands, while usually there is a good deal carried over. New has not made its appearance, but is daily expected. Since our last there has been but one sale, a lot of 110 bbls. at 55c.

JUNE 4.

New menhaden oil is arriving feebly, and the quality not being very choice, prices are lower. The sales are 25 bbls. at 52c.; 25 bbls. at

51c.; and 27 bbls. on private terms. The fishermen report plenty fish but a small yield of oil. Boston, June 2d, reports say:

"Menhaden oil remaining quiet; most of the old oil has been sold at 52 @ 53. The prospect for this season's catch can only be judged by the preparations made for doing the business, all of which are being carried forward on an extensive sale."

JUNE 11.

New menhaden has come to hand very slowly, and the market has not declined materially since our last report. We would quote 51@ 53c., with sales of 50 bbls. choice at 52c., and 50 bbls at 51@ 52c. Jobbing sales at 53c.

JUNE 18.

Menhaden oil comes to hand very slowly, the fish being scarce and yielding only about 1½ gallons per thousand; prices remain firm, with sales of 100 bbls. at 51c. for choice brown, and 52c. for select light; there is but little dark oil coming in and would bring 50c.

JUNE 25.

Menhaden is still in light supply and is consequently held firmly; the fish yield rather poorly but are more plenty and are growing fatter. Sales are 75 bbls. light, 25 bbls do.; 11 bbls. do., at 51c., and 20 bbls. brown at 50c. Boston reports, June 23, 1873, say:

"Menhaden oil of this season's catch has not yet made its appearance, and report says that there are plenty of fish on the coast of Maine, but the yield of oil very small; but with good weather the fish will soon be in good condition. Prospect is that we shall not want for menhaden this season."

JULY 2.

Menhaden oil is about 1c. lower at the close, though receipts are not large. We note sales of 150 bbls. at 50c., 51c. for choice, and 20 bbls. inferior at 48c.

JULY 9.

Menhaden is now coming in more freely and has fallen off in value; last week sale was made of 300 bbls. at 50 @ 51c.; but yesterday and to-day 150 bbls. were sold at 45 @ 47c.

JULY 16.

Menhaden oil has up to last week come to hand very sparingly, and the price was held up till toward the close at 45c.; but with more lots pressing in, sales were made of 52 bbls. at 45c.; 33 bbls. at 43½c., and this week 300 bbls. at 42½c., at which price the market closed.

JULY 23.

Menhaden oil has not come in freely, but buyers are holding off, as the market for their product is dull, and in consequence the price is easier; last week a lot of 50 bbls. sold at 42, but yesterday 38 bbls. sold at 41, and to-day 50 bbls. at 41c., at which the market seems to be steady, as 40c. has been bid and refused, though should receipts be large a further decline may be looked for.

JULY 30.

Menhaden oil rules steady at 40c., with not much coming in. The increased facilities which the fishermen have this season have been of little account thus far, the oil made being less than at the same time last year; still the fish yield fairly, and if they were abundant the production would be very large. Dealers have bought very sparingly, as their trade has been small, and the price has steadily declined since the new oil made its appearance. Exporters could afford to pay the present price if freights were not so unusually high, and with lower freight-rates a good demand may be looked for from this source. How much the large seal catch will interfere with a market for this oil is not known yet, but should the catch of menhaden be large, oil would have to sell at such a price as would be paid by a foreign market. At what price our home dealers would be willing to stock up it is difficult to tell, they having different views as to future prices; but at the present all buy only sufficient to supply their present wants. Sales are 300 bbls. at 40@41c., the highest price last week.

AUGUST 6.

Menhaden oil has not come in very freely; all told, perhaps 400 lbs. for the week, 200 of which sold for home use on private terms, and the balance shipped.

The price remains steady at 40 @ 41c., and there is a difference of opinion as to whether the oil is held back or whether the factories are making but little; most of the trade are of the former opinion. Boston reports, Aug. 4, says: "Menhaden oil: some sales have been made at 45c for small lots, but the Maine manufacturers are firm and intend putting their price at 50c., and holding. Reports are conflicting in relation to the catch; do not think from all accounts that there will be as much oil as last year."

AUGUST 13.

Menhaden oil has not arrived freely, and is, consequently, a trifle firmer; the catch of fish is unusually small and the yield is only one and a half gallons per thousand. There have been sales here of 600 bbls. at 40 @ 41½c. as to quality, the market closing pretty strong at 41c. for nice oil. The Boston market is higher. Boston reports, Aug. 11, say: "Menhaden oil: there has been a sale of 500 bbls. at 45c., and the manufacturers have agreed to hold price at 50. Most of the Maine oil is being shipped to New Bedford, and parties make advances, which satisfies the manufacturers. By this means they will keep oil up to 50c."

AUGUST 20.

Menhaden oil is firmer, owing to small arrivals and a light stock in the hands of jobbers. The combination in the East also has a tendency to stiffen prices here. The fish are now reported very fat, yielding 10 to 12 gallons per thousand, but the catch is small. Sales 250 bbls. at 41½c. At the close there is none offering on spot, and one lot to arrive

is held as high as 45c., but this may be considered an extreme price; probably 42½c. is a fair quotation for choice oil.

AUGUST 27.

Menhaden has sustained the advance of last week and rules very firm. There is not much coming in, and jobbers carry small stocks, but a better supply may come in at any moment; and, in consequence, jobbers will not buy more at present rates than they require for immediate wants. Sales are 30 bbls. nice brown at 45c.; 50 bbls. choice light at 45c., and 150 bbls. on private terms, supposed to have been about 45c., at which the market closes.

SEPTEMBER 3.

Menhaden oil is very firm, with a small supply coming forward. All lots are taken as fast as they arrive. Sales are 65 barrels at 45c.; 40 barrels inferior on private terms; 31 barrels prime at 45c.; 25 barrels at 45 cents, and 35 bbls. to arrive at 45c. Boston reports, Aug. 25: "Menhaden oil remains firm, and sales of 300 barrels have been made at 48, and it is doubtful if any can be had now less than combination price, 50 cents. The weather has been very unfavorable for 10 days past, and the catch very light. The amount of oil taken this season only amounts to about 6,500 barrels, and the expense has been much greater this season, as the fish are some twenty miles away. The quality of the oil taken is very choice." Sep. 1st: "Menhaden: a sale of 700 bbls. prime Maine has been made at 48c. To-day a meeting is to be held, and price of manufactures will be put at 50 to 52c., and some say 55c. The catch for the past ten days has been very light. Some manufacturers are holding at 55c. Should two thousand bbls. be shipped, it would advance oil to 50c. firm. Five hundred bbls. are going this week from here to Liverpool, and I hear of other lots to follow."

SEPTEMBER 10.

Menhaden has been more plenty the past week, but is taken freely on arrival at firm prices, the jobbers being short supplied and having a good demand for their kinds from consumers. The sales are 495 bbls. at 45c. cash from dock, and would probably bring 46c. in shipping order; but we cannot expect any export demand at present prices for oil, unless freights and exchange should very much favor shippers. There have been two lots sent from this market this season—one of 190 bbls. on order and one of 100 bbls. on account of a factory. The season thus far has been an unsatisfactory one for those who usually supply this market, and should the fall catch not prove better, we will have to look to Maine for a supply for this market. The fall season is, however, often the best, the fish being usually very fat, and if they catch enough fish may make up for all deficiencies; the fall catch last year was small, however.

Boston reports, Sep. 8: "Menhaden continues firm. The manufacturers hold at 50c., but I do not know of any sales at that price; 48c. is the

highest that any large lots have been sold for. The catch is reported light for the past week.

SEPTEMBER 17.

Menhaden oil is firm and wanted, meeting with a ready sale at 45c. for nice brown or light oil. The fall catch cannot be determined yet, but we hear that the fish are said to be wild and do not school; a few weeks, however, will determine the fall catch. Sales here: 95 bbls. light oil at 45c.; 50 bbls. brown at 45c.; 35 bbls. light at 45c.; 40 bbls. at 45c.

SEPTEMBER 24.

Menhaden oil has arrived slowly, and is still firm in price; but with the present uncertain state of the money market and foreign exchange a reaction may take place, as anywhere near present rates there could be nothing done for export. The arrivals and sales have been 30 bbls. at 47c.; 120 bbls. at 45c.; 25 bbls. at 45c.; and 22 bbls. at 45c., which price is not to be obtained at the close, and 400 bbls. have gone into store. Jobbers of curriers' oils report rather less doing this week. Boston reports, Sep. 22: "Menhaden oil is held firm at 48 to 50, but no sales have been made over 48. The exportations still continue; 500 bbls. go to Liverpool this week."

OCTOBER 1.

Menhaden oil is dull and nominal; there have been fewer arrivals, all of which have, however, gone into store, as there are no buyers at more than 42c., while holders still ask 45c., though would probably shade this price for a cash offer. Boston reports, Sep. 29: "Menhaden oil: sales of several lots of 300 to 500 bbls. at 47 to 48c. and holders are now very firm. The catch for the past fifteen days has been better and fish fatter.

OCTOBER 8.

Menhaden oil is not coming forward, and the lots in store have not been sold. The market is nominally as quoted in our list. Sales of 21 barrels on private terms and a report of 75 bbls. for export at 42c., but we were not able to verify the report.

OCTOBER 15.

Menhaden oil is not coming in very freely, but the continued dull state of the market has caused a decline in prices, and at the close 40c. is the best price to be obtained. The home trade are not in the market at all. The sales are, 50 bbls. at 42c.; 56 bbls supposed to be at 41½c.; and 300 bbls. at 40 c., all prime lots, the latter for export. We learn that the Maine fishermen have closed their factories for the season.

OCTOBER 22.

Menhaden oil is very dull and not coming forward; only 22 bbls. have arrived, which sold at 40c.

OCTOBER 29.

Menhaden oil has not arrived freely, but with little or no demand the price has fallen off, and sales have been made of 46 bbls. at 38c., with more offering at the close at same price and buyers bidding 35c. This

evening we hear that 100 bbls. sold at 37½c. and 100 bbls. on private terms.

NOVEMBER 5.

Menhaden oil is very dull, and with none coming in we have no further sales to report; a lot on the way is offering at 37c.

NOVEMBER 12.

Menhaden oil is lower, but the lots that arrived recently have been generally stored, and there is nothing offering at the close at less than 35c., though a prime lot was offered at 33c. on dock, without finding a buyer.

A small lot of Southern oil of inferior quality sold at 30c.

NOVEMBER 19.

Mendahen oil is not lower than we quoted last week, but there is not much doing; jobbers are buying very sparingly, and there is not, as yet, much demand for shipment, but while the present demand from jobbers does not warrant stocking up, the unusually low price may induce them to anticipate their wants. There have been sales of 10,000 gallons for export at 32c., and 200 bbls. for home use at 33c.

Boston reports, Nov. 17: "Menhaden oil is held above the views of buyers. It is difficult to give the quotation in the absence of any sales of importance; last sale was about 38 for 250 bbls."

NOVEMBER 26.

Menhaden oil is quiet, but with no lots coming in the price is rather more steady, with sales of 100 bbls. light at 33c.; most holders ask 35c. from store. Brwon oil not being plenty this season will bring about as much as light. Boston reports, Nov. 24: Menhaden oil held above the views of buyers. It would be difficult to get an offer of more than 37 to 38c., and most of the holders will sell less than 42 to 40c.

DECEMBER 3.

Menhaden oil has become very much firmer, all the lots pressing for sale having been taken; holders ask 40c. The last sale was 150 bbls. prime light at 35c.; previously there was a sale of 100 bbls. at 34½c., prompt cash. It is difficult to give an exact quotation, but the probability is that no great quantity could be bought under 40c. Any action taken by the Maine fishermen, who meet in Boston to-day, may have some influence. Boston reports, Dec. 1: "Menhaden oil: the difference between the buyers and sellers still exists, and as curriers are not running on full time, not much oil changes hands. The manufacturers meet in this city Tuesday, December 2. Some agreement may be adopted in relation to prices for oil on hand and also that to be made the coming season.

DECEMBER 10.

Menhaden oil has advanced, closing firm at the asking price of last week, with considerable sales making. There are free buyers at prices

a shade below the asking rates, but holders are not shading 40c. on any lot; and most of them ask 45c. The Eastern manufacturers have combined at 45c., and this lends strength to our market. While the amount of oil held back by the manufacturers is thought to be considerable, and the demand from dealers been small, still there is a feeling that prices are low and likely to advance. The sales are 310 bbls. on spot, at 40c. Boston reports, Dec. 8th: "Menhaden is firmer and sales have been made of about 1,500 bbls. at 40 @ 41c.; it is now held at 43 @ 45c. The meeting of the oil manufacturers last Tuesday resulted in holding oil at 45, which they seem determined to carry out. There is to be another meeting next January in New York for the purpose of effecting a union with the Long Island and New Jersey associations, and making a uniform price among the different cities."

DECEMBER 17.

Menhaden oil has been more active, and 325 bbls. sold on spot here at 40c., and 800 bbls. to arrive on private terms. Boston reports, Dec. 15: "Menhaden remains firm, and sales have been made at 40c. for several hundred bbls. which have been floating about the market. When these lots are closed out it will be difficult to buy under 45c., a price at which it is held. A sale is reported of 500 bbls. at 42½c."

DECEMBER 24.

Boston reports, Dec. 22: "Menhaden-oil maintains its firmness, but not many sales have been made. Sellers are holding at 45c., which is above buyers' views."

DECEMBER 31.

Menhaden oil is not active, but remains firm in price, with not much coming forward. What action the fishermen may take at their meeting next week is not known, but the effect is certainly depressing. There have been sales since our last of 200 bbls at 40c., and to-day 80 bbls. at 40c. Boston reports: Dec. 29th, "Menhaden quiet; there does not seem to be any inclination on the part of buyers to pay the prices asked by sellers, and with the close of the year parties have no disposition to increase stocks. Sales have been very limited."

1874.

JANUARY 7.

Menhaden oil is quiet, but steady. Arrivals light. Last sale 140 bbls., at 41c.

JANUARY 14.

Menhaden oil is higher since the meeting of the manufacturers last Wednesday, and there are buyers at 42½c., and it is rumored that 43c. has been bid. There have been other sales than those we report, but they are for the present kept private; we note 175 bbls. on private terms; 100 bbls., at 42½c.; 50 bbls., at 42½c.; 4,000 gallons in Boston, and 50 bbls. pressed oil here, on private terms.

JANUARY 21.

Menhaden oil is higher and in more demand, but the advance checks sales for the moment. There are no lots to be had for less than 45c., with 44½c. bid and refused. There was a sale last Wednesday of 150 bbls. for export at 43c., and since 50 bbls. for home use at 44c., and 10,000 gallons in casks to arrive at 42½c.

JANUARY 28.

Menhaden oil has not been so active the past week, buyers and sellers being apart in their views; sales are 300 bbls., at 44c.

There are several lots offering at 45c., and buyers have bid 44c.

FEBRUARY 4.

Menhaden oil has been in good demand, and the market is very firm, with an upward tendency. There have been considerable sales during the past week, part said to be for export. We note the following lots sold: 1,500 bbls. Maine oil to come here; 1,500 bbls. to an Eastern manufacturer; 1,542 bbls. and 50 casks other kinds, and 400 bbls. direct from manufacturers are reported at 45c. The market closes at 45c. bid, and 47½c. asked.

Boston reports Feb. 2d: "Menhaden oil nearly all in first hands has been closed out at 42½ to 43c.; some are holding at 45c., but it does not find ready sale at this price."

FEBRUARY 11.

Menhaden oil has ruled quiet but firm, 45c. having been bid and refused; 47½c. is asked. Sales since our last, 382 bbls. at 45c. Boston reports Feb. 9: "Menhaden oil has been sold at 42 to 44c., and only a small quantity remains in first hands that is held at 45c."

FEBRUARY 18.

Menhaden oil has ruled quiet the past week, but is very firm in price, 46c. having been bid for shipment. The sales are 300 bbls. for home use, at 47½c. Boston reports, Feb. 16th: "Menhaden—a sale of 700 bbls. has been made on private terms; the curriers are not doing much, so the demand for fish-oils is very light, and prices are no higher than last week."

FEBRUARY 25.

Menhaden oil quiet and hardly so firm; 100 bbls. reported sold from a dealer's hands, at 47½c.; 50 bbls. from dock at 45c., and to-day a lot was offered on dock at 46c., but was not sold up to a late hour this afternoon.

MARCH 4.

Menhaden oil is quiet, and with a light jobbing demand, and dealers well stocked up, the tone is not strong. Sales of 50 bbls. for export on private terms, and 60 for home use at 45c., at which price there are other buyers.

MARCH 11.

Menhaden oil is dull, and but few sales are making; some lots arriving have been stored, as holders will not submit to any concession in

price. Buyers are all supplied for the moment, and will not pay 45c. Sales are 50 bbls. on private terms. Boston reports, March 9: "Menhaden oil is quiet, not much offering; it is held at 45c., but buyers do not seem to think they can pay it. Curriers remain inactive, hence demand for oil is very light."

MARCH 18.

Menhaden oil is lower, as some small lots continue to arrive, and are pressed for sale, the larger dealers being all stocked up for the present, and complain of dull trade. Holders generally look for better prices, and refuse to sell at less than 45c. There has been a sale of 170 bbls. for shipment at 42c., and there are some other lots said to be offering at this price to arrive. Boston reports, March 16th: "Menhaden oil is held at 45c. for choice; some lots a little below standard have been shaded; with only about 1,000 bbls. in first hands, if there is any business this spring oil must advance."

MARCH 25.

Menhaden oil has arrived very sparingly, and we have heard of no sales since our last; 45c. is asked, but buyers would not pay more than 43c.

APRIL 1.

Menhaden oil is very dull. There have been no arrivals, but it would have been difficult to place any quantity even at our lowest price. The only sale we hear of is 50 bbls. prime from second hands at 45c.

APRIL 8.

Menhaden oil dull; no arrivals, but the market is weak, and 41c. will now buy a small lot here.

APRIL 15.

Menhaden oil has been slow of sale, with some arrivals of Maine lots on this market. There are sales of some considerable lots, reported chiefly on private terms, some of which have been held here for some time. The sales foot up 1,255 bbls., part at 41c. for prime, up to 42½c. @ 43c. for Maine, and a resale of same at 44c. About half of these sales were for export, the advance in gold assisting this trade.

APRIL 22.

Menhaden oil is dull, and can be had at 41c., but there have been no sales of prime from first hands. Maine oil is held at 42c. Boston reports April 20: "Menhaden oil continues dull, and without any demand it is difficult to fix a price. There is oil going to be exported, and if the surplus should be sent away prices will be firmer and higher."

APRIL 29.

Menhaden oil is still very quiet, and we have only 250 bbls. to report sold at 41c. Boston reports, April 27th: "Menhaden oil quiet, and, as there has not been any large sales made, we cannot give price, but it looks as though it would be higher."

MAY 6.

Menhaden oil has been more active, holders meeting the views of buyers, with the approach of warm weather and the fishing season. Sales are 250 bbls. for export at 41c.; 400 bbls. for home use at 40c.; and 700 bbls. for home use on private terms. Boston reports, May 4th: "Menhaden—a sale of 400 bbls. for export was made at 40c., but it is held higher at close. The news from the seal fishery is of a very discouraging nature, and the first news is more than verified. This must advance menhaden and whale oils."

MAY 13.

Menhaden oil has been quiet, with small offerings recently. There has been some inquiry at late prices, but the only lots coming forward since our last have been small inferior ones, and sold at irregular prices; the new catch has been fair for so early in the season.

MAY 20.

Menhaden oil has ruled quiet with small arrivals. Prices have not improved. One lot of 175 bbls. came in during the week, and sold for shipment at 40½c., at which price there are buyers for export. The new catch is reported as very favorable, but none has as yet made its appearance in market. Pressed fish, sold to the extent of 50 bbls. at 44c. Strained choice menhaden oil is in some demand, and 25 bbls. sold at 47c.

MAY 27.

Menhaden oil is quiet; there is not much coming forward, but dealers will buy only such lots as they actually need. The new catch has been reported less favorable the past week on account of the cold and stormy weather. Sales are reported of 50 bbls. new oil, the first of the season at 40c., and and 160 bbls. old at 40c. Boston reports, May 25th: "Menhaden oil dull, and not much demand for home consumption; several lots have been shipped at about 40c."

JUNE 3.

Menhaden oil is beginning to come forward more freely; but holders have not as yet offered below 40c., and one lot of 50 bbls. is reported at that price. The new catch is reported as more favorable than any preceding year at this time, but manufacturers say it will not pay to make at much below present prices.

JUNE 10.

Menhaden has been offering freely, and some lots have been pressed for sale from dock, and low prices have been named on them. Buyers will not take hold except as they need for actual wants, and prices are low, without much business. Sales, 75 bbls. on private terms, and some small parcels at 37 @ 38c. from dock. There has been some inquiry for pressed for export, and 125 bbls. sold at 46c.

JUNE 17.

Menhaden oil is coming to hand freely and has to be sold at prices which exporters are willing to pay; there have been sales of 125 bbls.

at 38c. and 500 bbls. for export on private terms. The fishing is said to be very favorable and the make large. Boston reports, June 15th: "Menhaden oil, small sales at 40c. The demand is light, as curriers are doing comparitively nothing. The eastern manufacturers are making preparations for doing a large business, and intend commencing in a few days if the fish should arrive."

JUNE 24.

Menhaden has been offered freely and closes easy, though there are buyers for export at better than the lowest price, which was a lot of 140 bbls. prime, at 35c. The market closes, we think, at about 36c. There is a fair demand for pressed oil.

JULY 1.

Menhaden oil has not come to hand quite so freely of late, and buyers begin to think that better prices may rule. There have been sales of 550 bbls. at 35 @ 36c., part at the latter price was for export, and we would quote the market firm at the close at 36c. and some of the fishermen asking higher prices. Boston reports, June 22d: "Menhaden oil—Some 400 bbls., all that remains of last season's catch on the coast of Maine has been shipped to Liverpool during the past week. There have been no sales of new oil; prices asked are 37 @ 38c. The weather has been such as to prevent taking any fish the past week. All are anxiously looking to the Maine fisheries for a supply of oil, which have failed them from seal fisheries and cotton-seed." Boston reports, June 29th: "Menhaden oil—The catch of fish has commenced on the coast of Maine, but the quality is such that the yield of oil is small. The expense of manufacturing oil is so great that, unless oil should bring 40c. or upward, it will be unremunerative to the makers of oil."

JULY 8.

Menhaden oil continued to increase in firmness following the date of our last report, and sales have been made of fully 1,000 barrels chiefly at 37c., and largely for export. Many of the fishermen are asking 40c., and are not offering to sell at less; if the receipts increase this week again the price will probably decline, but should they continue to be only moderate 40c. would prebably be reached.

JULY 15.

Menhaden oil has come forward a little more freely, and as the demand is not urgent for either home use or export prices are a trifle easier. There have been sales of 150 bbls. for export at 36c. At the close 36c. is asked and 35c. has been bid, and sales made of 123 bbls. for home use at 35c. Boston, reports July 13th: "Menhaden oil—There has been a sale of 1,000 bbls. at 38 @. 39c. of this year's catch, but at the close fishermen are asking 40c. The weather has been very unfavorable the past week, and should it continue it will have a tendency to advance the price of oil. Much depends upon the results of the fishing for the next three weeks. The cost of oil has been increased materially by the introduction of steamers, and 42c. is a low price for nice Eastern oil."

JULY 22.

Boston reports, July 20th: Menhaden oil—There are orders to buy at prices which the fishermen will not accept. The catch has not been very large during the past week, and the fishermen hold their oil firm at 40c. At the close I understand several lots are being exported, and should a large quantity be exported it would make prices firm here."

JULY 29.

Menhaden oil has been quiet with but little coming forward; the price is steady with 35c. for brown, which is the only kind we are now receiving. The feeling among all parties is that the present is as low as prices will go, and we hear that some of the manufacturers have closed their works on account of the small yield of oil from the fish; as little as one gallon to the thousand is reported in some localities. The sales are 300 barrels at 35c., and 50 barrels at 35½c. Boston reports July 27th, "Menhaden quiet; there are some 700 bbls. being exported, and price remains nominal. Fishermen do not care to sell at anything less than 40c., and buyers will not pay it; all wanting."

AUGUST 5.

Menhaden oil comes forward very slowly, this being what might be termed "between runs," the fish being scarce about the Long Island and Connecticut coasts. Since our last report there have been sales of 150 bbls. at 36c. f. o. b.; 140 bbls. on dock at 35½c., and 75 bbls. pressed at 40c.

Boston reports, Aug. 3d: "Menhaden Oil—The manufacturers are holding nice oil at 40c., but no sales are made; some 500 bbls. have been sold at 38c. and some reported at 36 @ 37c.; the oil being made now is much better in quality than last year at this time."

AUGUST 12.

Menhaden oil is not coming to hand very freely and rules firm in price; a choice light oil is particularly wanted and commands readily 36c., while an oil of dark color will hardly bring 35c. Exporters are in the market. Sales are 70 bbls. choice at 37c. free on board; 400 bbls. to at arrive 35½ @ 36c.; 45 bbls. at 35c. and 20 bbls. at 36c.

Boston reports, August 10th: "Menhaden oil—A sale of 1,000 bbls. has been made at about 35c. The catch has been fair the last week. Dealers stand back and will not buy at 35c."

AUGUST 19.

Menhaden oil is firm in price, as not much is coming forward. There have been sales of 300 bbls. at 35c. for brown, and 36c. for light; in shipping order, free on board, 37c. would probably have to be paid. Boston reports, August 17th: "Menhaden oil—Sale of 500 bbls. for home use at 40c., and for export a sale of 500 bbls. at about 36c. There has been a large quantity exported, taking all the oil as fast as it is made, and it looks as though a better price would be obtained later in the season."

AUGUST 26.

Menhaden oil has come forward rather more freely, but has been taken at about steady prices for home use and export; at the close some lots are offering, and 35½c. will buy nice oil. The sales have been about 800 bbls. at 35c. for brown, up to 37c. for light, free on board. Boston reports, August 26, "Menhaden oil is being shipped freely, and sales have been made at 35 @ 36c. for export. There does not seem to be much activity for home consumption as yet. The price agreed upon by the oil association at its last meeting was 40c."

SEPTEMBER 2.

Menhaden has been quiet, with only one lot of fair brown oil sold for shipment, 83 bbls., at 35½. The other lots which have arrived have been delivered former contracts. Boston reports, Aug. 31, "Menhaden oil is firmly held by manufacturers at 40c., but for export a concession of a few cents would be made. There has been 3,000 bbls. exported this season from here, which has taken all the surplus oil."

SEPTEMBER 9.

Menhaden oil has come in rather more freely the past week, and our advices are that the catch is better of late, and the season's production promises to be fully up to last. Prices remain without change, as the consumptive demand is rather moderate and the demand for export, of late, has fallen off somewhat. The sales since our last are 600 bbls. brown and light brown for home use at 35 @ 35½c.; 200 bbls., as it runs, for home use, at 35c.

SEPTEMBER 16.

Menhaden oil has not come forward very freely of late; the catch is said to be small at the present time, on account of the fish being wild. The demand has not been large, and sales have been made of about 250 bbls. brown, at 35c. or 36c. for light; also some lots sold at 35½c for light and brown mixed. Some parties think that this oil is a good purchase at the present price, and we hear of reports of some large transactions, footing up several thousand bbls. direct with the fishermen.

Boston reports, Sep. 14th: "Menhaden oil.—The large sale of several thousand barrels which took place some ten days since has had a tendency to make the market firm, manufacturers holding at 42½c., but dealers are not disposed to pay it, so no sales."

SEPTEMBER 23.

Menhaden oil has not arrived during the past week, owing to the storm, and we hear of no sales; the price remains firm, but dealers and exporters are not anxious for present wants.

Boston reports, Sept. 21: "There is a disposition among the manufacturers to hold oil at 40 @ 42c., but buyers cannot be found at those figures. Curriers are doing but a little, and do not talk as though they would want much oil. Unless there should be a start in trade, prices must rule low."

SEPTEMBER 30.

Menhaden oil has not come forward at all freely, and holders ask an advance on lots on the way. We hear of 300 bbls. offering to arrive. Buyers report a quiet market and show no willingness to meet sellers. We hear that fish are abundant but the yield of oil small.

Boston reports, Sep. 28th: "Mendaden oil remains without activity. The views of buyers and sellers do not harmonize. Manufacturers are holding at 40c. and dealers will not pay over 36 @ 38c."

OCTOBER 7.

Menhaden oil closes firmer, with dealers rather inclined to stock up. We have conflicting reports from the Boston market with reference to Maine oil. Our correspondent does not give us any sales at the asking price of holders, but trustworthy parties here say that 900 bbls. "Gallup" make were sold there to go to Gloucester at 40c. The sales here are 150 bbls., at 35½c.; 100 bbls., at 35¾c.; 370 bbls., on spot, at 36c.; 12,000 gallons, to arrive, at 36c., and a report of 70 bbls. very choice, at 37c.

Boston reports, Oct. 5th: "Menhaden.—There is a stand-still, owing to the difference between the views of buyers and sellers, one side holding at 40c. and the other only offering 35 @ 36c. The fishing season is nearly over, and it is about time to get results of the season's work."

OCTOBER 14.

Menhaden is very firm and the tendency is upward, with a demand both for export and home use. The business the past week has footed up 650 bbls. at 37c. for brown and 38c. for light, including 250 bbls. for export. At the close 40c. is asked and 38c. would be paid.

Boston reports, Oct. 12th: "Menhaden oil.—More demand from dealers, and prices are 38 @ 40c. Manufacturers are thinking of advancing the price to 45c.; if they should it would be holding it out of the market. There have been sales of several hundred barrels at 40c.

OCTOBER 21.

Menhaden oil is higher; the news of the very light catch of Arctic whale oil was the immediate cause of an advance of about 2c. There are now many buyers and few sellers. There were sales following our last of 100 bbls. brown at 37½c.; 350 bbls., for export, at 39½c.; and 300 bbls. Maine oil, at 42c. At the close the market is very much unsettled, but the tendency is upward. Boston reports, Oct. 19th, "Menhaden oil is firmer and is selling at 38 @ 40c., although manufacturers are holding at 40c."

OCTOBER 28.

Menhaden oil is again firmer, and toward the close there was considerable excitement, owing to dealers stocking up. The market closes strong, with many buyers and few sellers. Sales are 78 bbls. ordinary, at 42½c.; 100 bbls., at 43c.; 150 bbls., at 43c.; 90 bbls., at 43½c.; 400 bbls. Maine oil, at New Bedford, at 42c. cash; 600 bbls. do., light colored, to come

here, at 42½c. cash; and later we hear that a further sale has been made in New Bedford, to come here, of about 1,000 bbls. more.

Boston reports, Oct. 26th: "Menhaden oil is decidedly firmer, and held at 42½ @ 45c.; sales of 1,000 bbls., at 40c. and 42½c., and holders are certain that it will bring 45c. within a short time. The season has closed, and the oil has been placed with the exception of about 2,000 bbls."

NOVEMBER 4.

Menhaden oil is rather more quiet, and we think the upward tendency checked for the present. The recent large sales supplied those who were short. For the last few days the fish have been very fat and much handsome oil has been made from them, and while we believe the stock to be undoubtedly small, we think that it is generally underestimated.

Boston reports, Nov. 2d: "Menhaden oil firm and scarce. Sales have been made at 42c., and at close 45c. is asked, and very little oil in the market. Should a brisk demand spring up this market would soon be cleared out."

NOVEMBER 11.

Menhaden oil is easier than at the date of our last. The unusually fine weather during the week has been favorable for taking fish, which have been very abundant, but we learn are becoming less plenty toward the close, and that some of the boats' crews have stopped for the season. Buyers have for the present a full supply, and sellers have been obliged to accept as low as 40c. for brown and 41c. for light oil to-day, though this would seem to be bottom, as this price is bid by others, and most holders ask from 43 to 45c. When fishing ceases entirely there may be an improvement in prices again. There was a rumor in the market about two weeks ago that most of the menhaden in the English markets had been bought for American account. This proves to be a fact, as we now learn.

NOVEMBER 18.

Menhaden oil has again become easier, and at the close nice light oil cannot be quoted at better than 40c. One party claims to have been bid this price for shipment, while from an equally reliable source we are informed that a cargo of 400 bbls. was offered at this price, and the best bid being 38c., it was returned to the manufacturers' factory. Some parties who have oil stored in this city are holding at 45 @ 50c. The close is quiet. The sales during the week have been 500 bbls. Maine oil, in New Bedford, at 42½c.; 60 bbls. choice Long Island sold here at 41c., and 150 bbls. at 40 @ 40½c.

Boston reports, Nov. 16th: "Menhaden oil is selling at 42c.; stocks light, and should business spring up oil will advance."

NOVEMBER 25.

Menhaden has not been pressed for sale the past week, which would, however, have had a bad effect on the market. Receivers are looking about for export orders to relieve our market. Exporters claim that they

cannot pay 40c., which is the price asked. There have been sales of 400 bbls. very choice Barren Island, at 40c., for home use, and 175 bbls. on private terms.

Boston reports, Nov. 23d: "Menhaden oil is quiet, with a light demand, but prices are firm; sales have been made of 1,000 bbls., at 42½c., in New Bedford, to go to Gloucester and New York. Stock of oil in Boston very light."

DECEMBER 20.

Menhaden oil is very quiet and the price remains nominally unchanged, sellers not pressing goods for sale, and buyers not anxious to take hold, having sufficient to supply their wants for the present. Sales 2,000 gallons, at 40c.

Boston reports, Nov. 30th: "Menhaden oil is firm, and the price remains at 42 @ 45c., with light stock, and should business start up oil must advance to 45 @ 50c."

DECEMBER 9.

Menhaden has been quiet, with not so much offering. There is no particular change to report in prices; 47 bbls. sold on private terms.

Boston reports, Dec. 7th: "Menhaden remains as last reported, with a small supply and a smaller demand; oil held at 42 @ 45c. without any sales."

DECEMBER 16.

Menhaden oil has been very quiet for the past two weeks, and the tone is barely steady. A lot of 300 bbls. sold at a private price; 40c. is probably the full value of nice light oil. We hear that a cargo is on the way to this market.

Boston reports, Dec. 14th: "Menhaden oil.—A sale has been made at about 42c. for 200 bbls. made at Narragansett Bay. Maine oil is held firmly at 42 @ 45c., and it looks as though oil would soon be worth more than these prices, as the carriers are more active."

DECEMBER 23.

Menhaden oil has been quiet all week, and we only hear of 70 bbls., at 38½c., cash; 80 bbls. were shipped on order.

Boston reports, Dec. 21st: "Menhaden oil.—No sales to note during the week, but holders are firm at 42 @ 45c."

DECEMBER 30.

Menhaden oil is quiet and easy in price; one lot of 200 bbls. and one of 25 bbls. have sold since our last at a private price. We quote the market about 38c. for good, sound oil.

Boston reports, Dec. 28th: "Menhaden oil is quiet, and will be so until after the commencement of a new year. No sales; asking 42 @ 45c."

1875.

JANUARY 6.

Menhaden oil is dull, and sales are very few; prices nominal.

Boston reports, Jan. 5th: "Menhaden oil dull, and not much demand, although oil is held firmly by the few manufacturers that have not sold their product, at 42 @ 45c."

JANUARY 13.

Menhaden oil is in a position rather difficult to report. There are no lots on spot offering, and to arrive 40c. is asked, which buyers as yet are not willing to pay, but 38c. has been bid. There will probably be something done after the manufacturers' meeting to-morrow. We have not heard of a single sale for a week. The last lot was reported at 39c. by seller and 38c. by buyer. We hear that 130 bbls. of light, pressed, have been sold for shipment at 44c.

Boston reports, Jan. 11th: "Menhaden oil remains quiet, without any demand, and the price is nominal."

JANUARY 20.

Menhaden oil is firm, but quiet, at 40c., at which price there are sellers. Buyers have not as yet made up their minds to pay this yet, but there seems to be every prospect that a higher price will be reached before long. The sales are 100 bbls. prime Western at 40c., and we hear of a lot of inferior having sold in New Bedford to go to Boston, 200 bbls., at about 38c. We also hear that a fisherman has bought 500 bbls. on speculation at 40c., but we were unable to learn when it was to be delivered.

JANUARY 27.

Menhaden oil is very quiet; neither buyers nor sellers being inclined to make any concessions at the present time. The market, however, may be quoted very strong at 40c., and most holders ask more. Since our last there has been but one sale, from a dealer to a dealer, of about 7,000 gallons in casks, at 42c. from store. Boston reports, Jan. 25th: "Menhaden oil is held more firmly at 45c. since the meeting of the oil manufacturers held in New York; some sales have been made at 40 @ 41c. by parties that wanted to realize."

FEBRUARY 3.

Menhaden oil is dull and very slow of sale; in fact, there have been no sales, and prices are hardly more than nominal.

FEBRUARY 10.

Menhaden oil has been in more demand, and we look for an active business within the next week or two. There have been sales reported since our last of 500 bbls. of Western oil, at 40c., for March delivery, and this afternoon we hear that 511 bbls. sold at 41c., and about 1,000 bbls. more on private terms; the advance in gold caused a firmer feeling.

Boston reports, Feby. 8th: "Menhaden oil.—There seems to be more demand, and we note a sale of 2,000 bbls. Maine, at 45c., in New Bedford, and a sale here of 50 bbls. at 45c. Should an active demand arise from consumers it is thought that oil would go to 50c., as all the oil is in the hands of a few manufacturers, and their views are that prices will be higher."

FEBRUARY 17.

Menhaden oil can hardly be quoted higher, though one dealer has re-

cently taken about 2,300 bbls., part reported in our last. The price ranged from 35c. for inferior oil up to 40½c., and not 41c. as reported in our last. The close is firm, and all the lots at 40c. have, we think, been taken.

FEBRUARY 24.

Menhaden has been quiet since our last, the buyers of last week having taken all lots offered at about 40c., and holders now ask 43c. for nice light oil.

Boston reports, Feby. 22d: "Menhaden oil.—A sale has been made, to go to Gloucester from New Bedford, of 200 bbls., which will cost 46½c. delivered. No stock here in first hands."

MARCH 3.

Menhaden has been quiet the past week so far as sales go; there has been some inquiry, however, but buyers have not got their ideas up to sellers. Holders ask from 42 to 43c. for ordinary western oil.

MARCH 10.

Menhaden oil is not offering on spot, but is not wanted; 42c. is asked, to arrive, for a lot of 500 bbls. No sales.

Boston reports, March 8th: "Menhaden oil held at 45c., and some sales reported in New Bedford at that price. If a demand should spring up from consumers, oil must advance to 50c."

MARCH 17.

Menhaden is as dull as any article on our list. A cargo came to hand from Barren Island, but had been sold a long time ago. We expect a cargo of 5,000 bbls. from that place in about two weeks, which will be sold on this market. The price here is nominal at 40 @ 41c.; the lower price would probably be paid for good oil; the higher price might possibly be paid for very choice.

MARCH 24.

Menhaden oil has been dull, and up to to-day there has been but one sale of 60 bbls., choice, from second hands, at 42c. To-day a lot of 200 bbls. sold, to arrive, at 40c. for prime, subject to approval. This is about the price lots will bring on this market, and we do not look for any important advance on this price.

MARCH 31.

Menhaden oil has been more active the past week, and all good lots offering at 40c. or thereabouts have been taken. Sales reported are 500 bbls., choice, to arrive, at 40½c.; 250 do., at 40c.; 115 do., at 40c., and 150 do., part inferior, at 35c., and prime, at 40c.

APRIL 7.

Menhaden oil has ruled quiet, and we have no sales to report since our last; buyers will pay 40 @ 40½c. for nice light-colored oil, while holders would ask 41c.

APRIL 14.

Menhaden oil has ruled quiet since our last, without any particular change, and but few sales are making. There have been several arrivals

of cod oil recently, which meets with a steady sale. Boston reports, April 12th: "Menhaden oil is very quiet; curriers are doing little; hence the demand is light. The manufacturers ask 43 @ 45c., and dealers offer 40c."

APRIL 21.

Menhaden is strong, and in rather more demand, with a sale of 130 bbls. brown oil at 40c., while light would probably bring 41c. Boston reports, April 19th: "Menhaden oil is held firmly by manufacturers at 43 @ 45c., but sales are light. Dealers are willing to pay 40c. Some sales have been made on private terms, probably at about this price."

APRIL 28.

Menhaden oil has taken quite another turn, considerabls lots having been sold for shipment; and now that most other oils have advanced, the prospects are that the advance in menhaden will be maintained, even though the early fishing should be very good. The sales since our last have been as large as at any previous time, and create considerable excitement. The particulars of the transactions have been 1,600 bbls. Maine oil, in New Bedford, for export, on private terms, and 3,300 bbls. do., for home use, at 42½c. In this market the sales have been 150 bbls. ordinary, at 40c.; 600 bbls. do., at 41c.; 100 bbls. inferior, on private terms, and 50 bbls. Maine, at 44c., with 45c. asked for the same at the close.

MAY 5.

Menhaden oil has ruled firm in price, and some of our dealers have been buying quite freely and paying the advance asked by holders. The stock is now reduced to a small amount in first hands. The fishermen of Long Island, Connecticut, &c., will "try their luck" on the 15th of this month, and the immediate future of prices depends somewhat on the first catch. Sales here of 150 bbls. Maine oil, at 45c.

MAY 12.

Menhaden oil is just between seasons and hard to report. Some of our dealers have good stocks and some very little. The recent large sale in New Bedford, at high prices, it was thought would have advanced prices here, but we do not notice much improvement. The fishermen, generally, put out their nets yesterday, and expected large hauls if the weather would prove favorable, and the present indications are that there will be a season of warm, bright weather. We hear that some fish have been taken at Greenport, and oil in small quantities is expected here in ten days or two weeks. The success of the early catch will, without doubt, have a great influence on prices. Of course all the first oil is brown and light colored; Maine will not be affected by it, but of this kind there seems to be a good supply in the hands of dealers. Since our last two lots were offered, to arrive, both near at hand, and one of 300 bbls. sold at 41 per cent., and 140 bbls., now in, at 42 per cent. A nice sweet lot of brown was offering at 43c., but could not be obtained.

MAY 19.

Menhaden has been a little unsettled. Holders have been anxious to get rid of stocks before the new catch came to hand, and yet were unwilling to make any important concession. The first new oil of the season came in to-day, two lots, one of 37 bbls. and the other of 14 bbls.; the last lot was of very inferior quality, and brought 39c.; the other lot has not been sold as yet. The news from the fishermen is not favorable, no fish being caught on several days last week, and the yield small. This may be looked on, however, as interested information, with the worst side shown. The fact of 51 bbls. coming in to-day shows that some fish must have been caught. The sales of old oil are 1,000 bbls. Maine oil, in New Bedford, at 42½c.; 150 bbls. dark and brown, here, at 41c.; 105 bbls. dark pressed, at 42½c.; 50 bbls. very dark gurry, at 20c.; 40 bbls. shore oil, at 50c. Boston reports, May 15th: "Menhaden.—As the season is approaching when new oil will be coming in, the market is just now a little easier. A few porgy have already been caught in Long Island Sound. We note a sale at New Bedford of 1,000 barrels, comprising about all the stock of Maine oil in first hands. The quotations to day are 40 @ 43c."

MAY 26.

In all, the arrivals this season have been about 230 barrels of new Menhaden oil, most of which is now on dock unsold. After our last, two lots, of about 35 bbls. each, brought 40c.; one was unusually handsome for oil caught at this season. Holders ask this price at the close and future prices depend upon the catch for the next few weeks. We hear from a reliable and thoroughly-posted fisherman that since last Tuesday there have been hardly any fish taken; previous to that good hauls had been made, but the fish yielded only about two gallons. We hear that exporters can pay about 36c., and some buyers intimate that they will hold off till the export price is reached.

JUNE 2.

Menhaden has come to hand to the extent of about 150 barrels since our last. Holders ask 40c. for good new; buyers' ideas are not more than 38c., and 30 bbls. were reported at about this price. The other lots have not been reported as sold.

JUNE 9.

Menhaden oil is quiet, with new oil worth about 37c. for prime quality. The catch of fish is small and the yield light. The arrival of oils has been limited, but trade with the dealers has been dull and their wants small. During the week we hear of the following sales: 125 bbls., 50 bbls., 70 bbls.; and 52 bbls., all at 37c.; 100 bbls. on private terms; and 75 bbls., not sweet, at 36c. We also note a sale of 50 bbls. domestic cod, at 58c., and 13 bbls. strictly pure do., at 65c.

JUNE 16.

Menhaden oil has not been plenty the past week, the cool weather not being favorable for catching. The fish are reported as yielding very

little oil, which is of only fair quality. The tanners are very dull, and consequently the consumption of such oils is very light; and dealers report a very dull trade in tanners' oils. Owing to this fact, unless we have an export demand, prices will have to rule very low. Most of the dealers carry a good stock. Sales during the past week that we have reported to us are 46 bbls., at 36c.; 24 bbls., at 36c.; 28 bbls., at 37c.; and 60 bbls., at 37½c. No sales of cod to report.

JUNE 23.

Menhaden is quiet; the demand is light, but there is not much coming forward. The fish are uncertain and the yield small. We hear of a sale for export of 125 bbls., at 36c.; 200 bbls. for home use, at 37c.; 29 bbls., at 37c.; 67 bbls., at 38c.; and 50 bbls., at 36c.

JUNE 30.

Menhaden is dull here, as the demand for tanners' oils is very light. Prices have declined; and sales have been made of 160 bbls., at 35c. and 100 bbls., at 35½c., both cash. The fishermen are doing fairly, and unless we have more home trade, we will have to look to foreign markets for an outlet. We hear that some orders are in the market now, and that one party is busy filling quite a large one which has not been reported.

JULY 7.

Menhaden rules quiet and steady at 35c., with some export demand at this price. The lots which come to hand and sold are 90 bbls., 30 bbls., 25 bbls., 50 bbls., 100 bbls.; part of the last two brought 36 @ 37c. from a consumer and part for export.

JULY 14.

Menhaden has come to hand in fair quantities, and is taken by home and export buyers at 35c. for good oil, which seems to be the market price, buyers being unwilling to pay more and sellers refusing to take less. The shipments of over 1,000 bbls. to Glasgow last week are said to have been pressed Maine oil, and sent on owners' account. The sales here have been 350 bbls., in lots, for export, and 490 bbls. for home use, all at or on a basis of 35c.

JULY 21.

Menhaden is quiet at 34@35c. Following our last, there were two lots of oil offering to arrive—one from Maine, of about 500 bbls., and one of about 150 bbls., Western. A bid of 35c. was asked for these and could not be had in this market, and then 34½c., cash, would have bought. Indeed, the market was weak, owing to a decline of £2 per ton—the market being now £33—in London, and a falling off in the price of gold here, which caused shipping limits to be reduced to about 34 c. At the same time there were two home buyers ready to take small lots of nice oil at 35 c. on the spot, but their requirements would be supplied with a very small quantity. On Thursday the Maine oil on the way to this market was disposed of to a New Bedford refiner at 35c., and since there have been the following sales: 200 bbls., on spot, at 34½c.; 500 bbls., to arrive, at 34½c.; 50 bbls., on spot, at 35c.; 50 bbls.,

on spot, for export, to complete an order, at 35c.; and a parcel of about 50 bbls., select, on private terms, probably at about 36c.

Our reports from the Western fishermen are that the fishing is poor, and the yield only about 2 @ $2\frac{1}{4}$ gallons per thousand. From Maine we hear that the fish are rather scarce, and the yield about 4 gallons per thousand. The Maine fishermen seem to be adopting a different course this season from last. Last year they carried their stock over into the present catch, but they are sending forward their new oil as early as possible now.

JULY 28.

Menhaden oil has not arrived so freely, but one lot that we heard of last week coming on the market. The demand has been entirely for home buyers, and they have not wanted very large parcels. The decline in gold caused shippers to reduce their limits to 33c., but the advance to-day may help matters, though no effect is yet noticed. To-day three lots came to hand; in all, a little more than 300 bbls. 130 bbls. of this sold at $34\frac{1}{2}$c.; and 100 bbls., hardly prime, sold at 34c. The other lot is still unsold. Being mostly light-colored, it is held at a higher price. The lot mentioned as having come to hand last week was 135 bbls., and brought $34\frac{1}{2}$c.

AUGUST 4.

Menhaden has not come to hand very freely, as the catch of fish is small and yield of oil light. In consequence, we are informed that some of the fishermen have closed their works till fall, or such time as the fish yield enough oil to make it pay. While the arrivals have been small, they have been all that the market could bear, and in some instances prices have been shaded a little. There is little or no demand for export, except at 33 c. for light oil. The sales are: 100 bbls. prime light, at 34c.; 66 bbls. do., at $34\frac{1}{2}$c.; 70 bbls., at $33\frac{1}{2}$c.; 62 bbls., at $33\frac{1}{2}$c.; 37 bbls., at 33c.; and 1,600 bbls. Maine oil in New Bedford, at 35c. The Maine make this season, thus far, has been about 5,000 bbls. The yield of oil per thousand fish on Long Island is an average of $1\frac{1}{2}$ gallons.

AUGUST 11.

Menhaden oil has come to hand fairly, and several lots of Maine oil have been offered for shipment. There is no difference in price between Maine and Western oil, the former being in comparatively larger supply. Dealers are buying sparingly, as their trade is dull, and the tendency of prices is downward, toward the price shippers can afford to pay, which, at the present, is said not to be more than 32c. for the choicest lots. This is very low; but the fishermen, said to be making less than former seasons, seem to be forwarding their oil pretty rapidly. On Wednesday, 500 bbls. of Maine oil sold at 33c., and 100 bbls. Western at same price. Thursday a straight lot of 1,000 bbls. Maine was offered at 33c. without finding a buyer. Since then there have been sales of 500 bbls. on private terms. At the close the market looks as though 30c. would be a near-future price.

AUGUST 18.

Menhaden is steadier, but we hear that fish are more abundant and fatter. Tanners are buying more oils. Exporters cannot pay more than 32c.; some lots could probably be sold at this price. The transactions since our last are 2,900 bbls. Maine oil, 900 to arrive in New Bedford and 2,000 bbls. here, at 33c.; 58 bbls. western oil to an out-of-town consumer, at 34c.; 80 bbls. do., at 32c., and 91 bbls. inferior, at 31c.

AUGUST 25.

Menhaden has not changed much in value since our last report. It seems to be about as low as it ought to go, and yet if the catch is large and is forced on the market it may go lower, particularly as there is no export demand of importance, and foreign orders are at very low prices. This is now relatively the cheapest oil in the market. The sales during the week have been as follows: 800 bbls. of Maine, to arrive, at 32½c.; 152 bbls. Sound oil for export, at 32c.; 180 bbls. for export, at 31½c.; 30 bbls. do., at 32c.; 20 bbls. dark brown, at 31c.; 30 bbls. do., at 30c., and 25 bbls. poor, at 29c. A lot of 300 bbls. Maine oil came to a dealer direct.

SEPTEMBER 1.

Menhaden has not arrived in this market very freely the past week. All lots coming to hand have been taken without much urging, mostly for home use. The sales are 70 bbls. Sound oil, at 30c.; 100 bbls. do , at 30½c., both lots a little off from prime; 50 bbls. do. prime, at 31c.; 143 bbls., at 31c.; 150 bbls. for export, at 31½c., and 100 bbls. Maine, to arrive, at 32c. We hear that there are orders in this market for several thousand bbls. for export at 31c. It would relieve our market very much to place some full parcels in European markets. The oil is the cheapest grease in the market. We have just received a letter from a correspondent in the East, the pith of which we give, as follows: The fish are becoming plenty and yielding well. The stock at Booth Bay is 4,600 bbls.; at Round Pond, 3,400 bbls., and at other points in Maine, 8,000 bbls. The hauls of fish on the 28th inst. in Maine were said to have been sufficient to make a thousand bbls. of oil. Another correspondent writes that the fish are yielding 6 @ 8 gallons to the thousand, which is large.

SEPTEMBER 8.

Menhaden oil.—We have a report from Maine dated August 3d which says that the large hauls did not continue beyond the day mentioned in our last and part of another, when the fish fell off, and have since been quite scarce. There have been several shipments, in all amounting to between 2,000 and 3,000 bbls., to New York, Boston, and New Bedford to fill old contracts at 33c.; but now the larger holders have put up their price to 35c. Our market has been quiet, dealers having a fair supply, and, though arrivals have been moderate, no advance has been obtained till towards the close, when shippers have, we think, advanced

their limits somewhat. Sales have been made here of 170 bbls. Sound, 30½c.; 30 bbls., at 31c.; 50 bbls. brown, at 31½c.; 50 bbls. gurry and dark, at 20@28c., all for home use; 90 bbls., at 32½c.; 62 bbls. brown, at 31½c.; 300 bbls. on private terms, and 300 bbls. Connecticut, in Boston, at 33½c., all for export.

SEPTEMBER 15.

Menhaden has been taken more freely for export by parties in this market, who have slightly increased their limits. This does not seem to have any perceptible effect on prices, and dealers who generally have a supply will not pay any advance. The sales reported us are 156 bbls. Sound, at 32c.; 40 bbls. dark, at 31c.; 700 bbls. do., at 32c.; 175 do., at 33c. f. o. b.; 1,000 bbls. Maine, at 33c., and a cargo of about 3,000 bbls. f. o. b., at Round Pond, Me., at 32c., all, or nearly all, for export; also 260 bbls. Maine, in Boston, at 32½c., for export.

Our correspondent, under date of Sept. 10th, at Round Pond, Me., says: Very few fish have been caught, and the fishermen are much discouraged. A good deal of oil has been shipped from here to fill old contracts, and higher prices are asked.

New London, Conn., September 11.

Fish on the Connecticut shore have been quite plenty during the past ten days, and at Lyme and Mystic, where most of the fish-oil works are, the manufacturers have done well.

From Tiverton and Portsmouth, R. I., we hear that the fishermen have done very poorly for the past three weeks, and one of the largest manufacturers that he has made but little more than 300 bbls. this season.

Our advices are that most of the Long Island fishermen are doing well.

SEPTEMBER 22.

Menhaden oil has not changed in position much since our last. There have been very few arrivals, and none of these came on the market, having been sold previously. Dealers are not anxious buyers, and will pay no advance, as they have sufficient stock to meet all wants for some time to come, yet they would probably take any good lots that were offered at present rates, the season being so far advanced that the catch cannot be of much account on the western fishing coast, where it has been pretty poor all season. The Maine catch has no doubt been a good one. Exporters have taken some lots, but there are not many orders now in market. The sales since our last are 200 bbls. Sound, at 32c.; 53 bbls. do., fair quality, in two lots, for home use, at 31c.; and 50 bbls. prime, at 35c. Two lots, one of 200 bbls., at 32c., and one of 140 bbls., at 33c., f. o. b., were delivered to shippers this week. The sales were made some time ago. A vessel is daily expected with a cargo, which will come on the market.

SEPTEMBER 29.

Menhaden oil has come to hand very sparingly the past week, and our reports from the fishermen continue so unfavorable that the indications

are that higher prices will rule in the near future. A letter of recent date says that there are probably not over 1,000 bbls. on the Connecticut shore. This may be an underestimate, but all of our advices are that the amount is very small. The arrivals and sales here have been 100 bbls., at 33c.; 150 bbls., at 33c.; both for export; 146 bbls., at 32½c., and 100 bbls., at 33c., for home use. The lot reported in our last should have been 250 bbls. instead of 200.

OCTOBER 6.

Menhaden oil has been scarce the past week, the only arrivals going on former contracts, one for 180 bbls., for export, at 33½c., and one of 150 bbls., for home use, at 33c.; also a sale of 17 bbls., brown, at 32c. Reports from the fishermen are that there is very little doing, and the prospects are unfavorable. Some of the Maine manufacturers have sent their vessels to the west, but the roughness of the water will not permit them to haul their nets. The tendency of prices would seem upward, particularly for light-colored, and as high as 35c. might be paid for a nice lot. The late fishing may prove good, as it did last year; but at the present time the chances do not seem favorable. Exporters in this market say they can pay no advance, and the only orders we hear of are at 32c.

OCTOBER 13.

Menhaden has been rather scarce of late, and the tendency of the market is upward. A week will decide whether the fall catch will be good or not. At the present time fishing is very poor, but they expect better fish and more of them next week. The arrivals have been about 425 bbls., and 100 sold at 32c., 76 at 33c., 106 at 32½c., and 150 for export on private terms. Buyers will take all lots offered them at present rates. Bleached oil has been advanced, sales having been made of 50 bbls., at 47c., and held at 48c. now.

OCTOBER 20.

Menhaden oil is higher. The catch has not improved much and can hardly amount to a great deal hereafter. Several of the manufacturers report considerable losses in their business, and hope for a run of good fat fish yet. There have been no arrivals since our last, but a small cargo is expected. We think the next sales of good sound oil will be about 36c. Maine oil is now held at 40c. in New Bedford, there having been a cargo sold to arrive there of about 700 bbls., at 39c. Bleached is higher, and 50 bbls. have sold at 50c., for pressed.

OCTOBER 27.

Menhaden oil has been very excited, a movement having commenced following our last which ran up the price so that holders in the East asked above 40c., and sales were made here up to that price, while prices have shown no weakness, 40c. having been bid and refused here for a lot of Long Island oil on spot. The news of a good catch of whale-oil by the Northern whaling-fleet, and letters received to-day from Fall River, where the Maine fishermen are hauling, and also from Barren

Island, reporting plenty of fish and a large yield of oil, may cause more to be pressed on the market to obtain present rates, and a reaction may take place. The sales reported are 1,400 bbls. in New Bedford, at 37c.; 900 bbls., at 39c.; 500 bbls. on private terms, and 100 bbls. reported at 40c.; 1,000 bbls. of Maine oil to arrive here, at 40c.; 100 bbls. Sound oil to arrive here, at 34c.; 100 bbls., at 36c.; 150 bbls., at 37½c., and 142 bbls., at 40c. There has been much activity in bleached, and we hear of the following sales: 534 bbls., all at 50c., small lots now being held as high as 55c.

NOVEMBER 3.

Menhaden oil has been quiet the past week, but steady in price, even though the reports are quite favorable from the fishermen, who are said to have had a good run all last week. The season has so far advanced now that the catch from this out cannot be very great, and holders are firm in their ideas asking, and we hear of no lots offering for less than 42c., with sales of 850 bbls., at 40c. Part of last week large hauls of mackerel were made by the menhaden fishermen. We hear of a vessel being chartered last week and a cargo of menhaden sent to the East, the boats which caught them not having time to return with their load.

NOVEMBER 10.

Menhaden oil has come to hand more freely of late, as the catch is reported pretty good, but will shortly end. Dealers here take all that come to hand at 40c., but we do not hear of their being willing to pay any more. Sales are 450 bbls. on spot at 40c.; 300 bbls. for forward delivery, and 70 bbls. on spot on private terms, but no doubt at same price. The oil coming now is very handsome.

NOVEMBER 17.

Menhaden oil is firm, and there are free buyers. Most of the fishermen have stopped work. The stock held back is thought to be small, and prices may advance if trade should improve. We hear that the Maine oil in New Bedford is now held out of market. The sales are reported of 400 bbls., spot, at 40c.; 100 bbls. at 41c.; 220 bbls., to arrive, at 40c.; 31 bbls., dark, on spot, at 40c.; 50 bbls., light, to a consumer, at 43c. and 1,000 bbls. in New Bedford reported at 45c.

NOVEMBER 24.

Menhaden oil is high in New Bedford, and we hear that holders there ask 47½c., but our market has not advanced recently. Trade for tanners' oils is light, and dealers will not pay high prices. In New Bedford the oil is refined. The sales here are 245 bbls., to arrive, at 40c. for dark and 41c. for light; 25 bbls., dark, at 40½c.; 35 bbls., good, at 41c., and 140 bbls., selected, at 42c. In New Bedford a lot of 400 bbls. sold at 46c.

DECEMBER 1.

Menhaden oil has been in a hard position to quote. In the East prices are very high and stock scarce. The few lots coming here have

to be sold at about 42c., at which price dealers stand ready to buy, but as most of them have a good stock they are not willing to pay and advance on this, and 258 bbls. just to hand were sold at this figure, though we hear that there are some outside buyers willing to pay more. The fishing is all over, and one of the Barren Island makers has failed and is reported as making a bad showing. In Boston we hear that 100 bbls. Maine oil sold at 45c., and now none offering at less than 47½c.

DECEMBER 8.

Menhaden has ruled firm in price with a small supply offering, but jobbers carrying full stocks. All the oil in New Bedford, some 2,500 bbls., has been taken at a private price, and in Boston there remain only 100 bbls. unsold in first hands. The arrivals here have been about 750 bbls., part of which brought 41c.; also a resale of 200 bbls. at 45c. There are buyers at from 42 @ 43c. at the close for good oil.

DECEMBER 15.

Menhaden is in small stock in first hands, arrivals being light. The 500 bbls. reported in our last are said to have been bought by a Boston house on speculation at an average of about 42½c. There has since been an arrival of 75 bbls., which sold at 43c. to a dealer. The dealers of this city are all carrying a pretty fair stock and will probably realize a good profit on the oil they hold if the consuming trade at all improves.

DECEMBER 22.

Menhaden oil has not been received that we hear of since our last, most of the oil having been sent forward before. We have heard of but two transactions; a lot of 75 bbls. having sold to come from the factory when wanted, at a price not yet made, and 160 bbls. to arrive at 43c. We hear of a lot of Maine offering in New Bedford at 47½c.

DECEMBER 29.

Menhaden is firm in price, and all other fish-oils are tending upward. We hear that two of the contracts made some time ago for bleached were sold some time this month at a premium of $1 per bbl.

1876.

JANUARY 5.

Crude menhaden oil is in small stock, probably not over 750 bbls. in the hands of fishermen, 1,000 bbls. in first hands in New Bedford, and 750 bbls. in first hands here. The holders ask 50c., and will probably get it. There have been sales of 83 bbls. from store here at 47½c., and 50 bbls. rather poor at a private price, less than the other. All the products from menhaden are comparatively cheaper than the crude article.

JANUARY 12.

Menhaden oil has been taken fairly this week, and the price seems to tend upward, as the supply remaining in the hands of manufacturers

is very small. One large manufacturer has failed recently. During the week there have been sales of 350 bbls., part rather inferior, at 45c. as it runs; we also hear of a resale of 200 bbls. at a private price. Extra bleached menhaden is held as high as 60c., though ordinary is to be had at 55c.

JANUARY 19.

Menhaden oil rules firm in price, but owing to the small supply business is limited.

JANUARY 26.

Menhaden oil rules very quiet, but the small stock of crude keeps prices firm, and should there be only a fair trade prices would advance materially. There is scarcely any going into consumption. Holders here ask 50c., and we heard of 50 bbls. selected selling at this price, but have also a report of 70 bbls. choice having sold within a few days at 45c., though this is below the market at the present time.

FEBRUARY 2.

Menhaden dull but firm, and the manufactured kinds are generally held for more money.

FEBRUARY 9.

Menhaden is unsettled and nominal. To sell a comparatively low price would have to be taken; but there are no lots to be forced on the market. We hear at the close that one dealer is offering to resell, and that some parties who bought to bleach have stored their stock of crude, and have intimated their intention of selling it rather than manufacture, as the price of bleached is not enough higher to pay for bleaching. We hear of pressed and strained both selling at as low or less than the nominal price of crude.

FEBRUARY 16.

Crude menhaden oil is not moving as yet, but holders are firm while buyers are well stocked up and are indifferent, their trade being very light. There has been more doing in pressed, and we heard of a sale of 70 bbls. on private terms, and 50 bbls. at 50c., with holders asking 52c.

FEBRUARY 23.

Menhaden has been quiet, as a rule. At the date of our last we were informed that negotiations were pending for export, and on Wednesday a lot of 500 barrels—which had been held by a dealer—was sold, to go to Havre, at 48½c. This has the effect of stiffening prices, which before were nominal. The stock in first hands is very small, and if any large orders should come into market they could not be filled, except at a high price; at the same time a lot thrown on the market would have to sell rather low.

MARCH 1.

Menhaden oil is as quiet as can well be, no stock offering, no buyers wanting. Price nominally firm at 50c. Bleached and strained are very slow of sale.

MARCH 8.

Menhaden oil is in the same position it has been for a long time past, not enough doing to make a market. Dealers have a supply for their dull trade, and no further export orders in market. There are a very few parcels held by first hands, and these are not pressing for sale; only one do we hear offering at 48c. Dealers are generally inclined to work off stocks of bank and strails at quoted rates.

MARCH 15.

Menhaden has sold in this market since the lot for shipment at 48c., as follows: 50 bbls. at 48c., and 100 bbls. to arrive at 46c. There has been a sale in New Bedford of 300 bbls. at 46c. there to come here.

MARCH 22.

Menhaden has not sold since our last, notwithstanding some commercial journals reported sales of 2,000 bbls. This lot has *not* been sold, and is now offering. Several weeks ago a bid of 45c. was made on it delivered in New Bedford, but the holder refused to sell. We heard of 50 bbls. dogfish selling here at 47c. Tanners are buying very sparingly.

MARCH 29.

Mehaden is dull, none pressing for sale; no demand except at low prices. Holders ask 50c.; buyers would pay 45c.

APRIL 5.

Menhaden is generally quiet, but there has been a lot of 300 bbls. sold at a private price, reported at about 46c. in store.

APRIL 12.

Menhaden is rather uncertain. Fishing will commence in about a month, if the weather is warm. Trade is dull. The stock is light. Holders do not want to part with their goods unless at full or an advanced price, while buyers are inclined to act with great caution, and not take unless at a concession. Since our last, a lot of 160 bbls., said to be Maine rejections, sold on private terms, and to-day we hear a rumor that 1,000 bbls. of Maine sold in New Bedford to a manufacturer at 46c. or better. If this is so, it will leave only about 1,300 bbls. in first hands, and probably a very moderate stock with dealers. We note sales of 75 bbls. bleached, at 52c.

APRIL 19.

Menhaden has not sold since our last report, but the feeling is easier, and the choicest lots can now be had at 45c. The first fishing steamer will be started out the 27th of this month, by V. Koon & Son. The stock of oil is small, but probably more than can be sold before the new reaches the market. There was a sale of 100 bbls. bleached, at 50c.

APRIL 26.

Crude menhaden is in a peculiar position. If a large lot were forced on the market, a low price would have to be taken, and there are one or two large parcels which could be bought at easier prices, but the holders are not willing to accept any decline for small portions of them.

Buyers will not take more than they want from week to week, and, as a rule, prefer paying a little more money for a small lot than they could buy a large parcel for.

There is a rumor in the street to-day that 500 bbls. have sold at 46c., but one parcel, at least, can be had at 45c.; a sale of 50 bbls. at 46c.

MAY 3.

Menhaden is dull. We hear of no sales from first hands since the 500 bbls. which we reported last week, which was for export to France, and at a private price. A dealer sold 25 bbls. to a consumer at 48c. for choice.

MAY 10.

Menhaden is quiet and easy, prices tending downward. The fishing has not fairly commenced, but we have had two lots of new oil in; the first, 17 bbls., came last week to Cory & Co., and was refined; this week 40 bbls. came to T. G. Hunt, but has not been sold. The quality is good. The only sale we hear of is 150 bbls., good old oil, at 44c.

MAY 17.

Menhaden oil has declined during the past week, and closes at 35c. for prime new oil. The arrivals the past week of new have been about 600 bbls., of quality equal or superior to any ever before made. While our dealers carry but small stocks of old, the loss on this is very large, and they have not been in a position to materially lower prices for the manufactured kinds; but with a pressure to sell, the tendency is downward.

The oil catch promises to be large, the fish being very fat and yielding well. The probabilities are that as low prices will rule as last year, unless we have a good export demand. The sales are 25 bbls. bleached, at 50c.; 100 bbls. do., at 48c., and less would probably now buy; 100 bbls. old crude oil in New Bedford, to go to Boston, at 44c.; 325 bbls. old, here, at 41c.; 150 bbls. do., for export, at 37½c.; 200 bbls. do., at 35 @ 36c., and 17 bbls. at 35c.

MAY 24.

Menhaden oil has come to hand rather sparingly the past week, and the few lots on the way have nearly all been sold. The price is 35c. for good oil, and must be regarded firm under the present circumstances; but should there be any large hauls of fish, or the yield increase, prices must go lower. Our dealers carry a small stock, but are not inclined to buy any quantity at the present time. Should their trade improve, however, and the catch of oil continue light, they would come into market in about two weeks, and probably pay an advance. The latest report from Long Island coast, and the sound, is that the fish are not plenty, small, and yielding two gallons, poor quality. There is considerable speculation as to future prices, and it is generally believed with an average catch, such as last year, prices will range from 30 to 35c.; but should there be a catch equal to year before last, considerably less than 30c. would be reached, or a price low enough to induce exporters to

take large parcels. The sales, since our last issue, have been 260 bbls. to arrive, at 35c., and a resale of 90 bbls., and some selected on private terms. Bleached, pressed, are all easier, and somewhat irregular in prices, tending downward.

MAY 31.

Menhaden oil is firm under light arrivals, only two or three parcels coming in that had not previously been placed and reported. The news from the fishermen is, that at Barren Island the fishing is fair, but the yield only 3 gallons good quality. The east end of Long Island report few fish and little oil of poor quality. An arrival of 80 bbls. was placed, mostly for export, at 35c., and a parcel of 74 bbls., from New Haven, "Q" brand, as it ran, mostly light colored, at 35c. There has been a small sale of herring oil at 30c.

JUNE 7.

Crude menhaden has not arrived very freely, and the fishermen report few fish, but we are inclined to think that more are caught than reported. At the close we also hear of several parcels at the works offering for sale. Last week there were arrivals of 465 bbls. of fair brown oil, most of which sold to dealers; one lot of 150 bbls. was placed for export, all at 35c. In New Bedford, 3,000 gallons choice light sold at 36c.

JUNE 14.

We note a decided improvement in our menhaden oil market. Reports from the fishing grounds state that the fish are very scarce, and unless they become more plentiful most of the gangs will haul up as they are not able to pay their expenses, and are going behind every day. In the absence of positive sales it is a hard matter to give any reliable quotations; a prime lot would no doubt bring 36c. Dealers are on the lookout for small parcels of prime, but do not feel disposed to bid over the above price; a lot was offered at 37c., but was not taken that we hear of.

A letter to hand to-day says: "I give you our report for the past two weeks, which is probably identical with all the sound fishing, viz: The catch has been exceedingly small and the fish very poor, not yielding some of the time but about two quarts to the thousand. They improved slightly the latter part of last week, but are still in small quantity and comparatively poor. The Maine fishermen are just about commencing work, and unless they have better success there will be a scarcity of oil and an advance in prices."

JUNE 21.

Menhaden oil has continued to advance with small arrivals. The demand from dealers is not large, but their stocks became almost entirely exhausted, and were willing to pay higher prices. Until to-day there have been hardly any lots in, and though the steamer to-day brought several large parcels, most of them had been placed before arrival. The sales are 37 bbls. at 35½c., 30 bbls. at 36c., 50 bbls. at 37½c., 200 bbls. at 38c.,

and 64 bbls. at 38½c., all to arrive; on spot to-day 63 bbls. sold at 38c.; most of these last were sold as they run, not selected. Fishing advices are as follows: "Fish are quite plenty and fat, but are very wild and hard to get." Another report to hand to-day, dated June 19, says: "The catch of menhaden last week was the smallest catch of any week thus far this season in Long Island Sound. The few caught were better quality than for the preceding fortnight."

JUNE 28.

Menhaden oil has come to hand more freely, and the fishing has also improved; consequently prices are again lower and tending down. The sales are 42 bbls. at 38c., 27 bbls., the first from Barren Island, at 38c., 98 bbls. at 37c. and 75 bbls. at 35 @ 36c., closing with buyers at these lowest prices.

JULY 5.

Menhaden oil has come to hand more freely, and the fishing has also improved; consequently prices are again lower, and tending down. The sales are 42 bbls. at 38c., 27 bbls., the first from Barren Island, at 38c., 98 bbls. at 37c., and 75 bbls. at 35 @ 36c., closing with buyers at these lowest prices.

JULY 12.

Menhaden oil has not come to hand since our last report, except 93 bbls., which sold at 36c. for light and 35c. for brown, and 50 bbls. yesterday, which sold at 35c. as it run. The market is steady, and there are buyers at 36c. for good oil. We hear that while the fish are quite plenty they are very poor, yielding only one gallon per thousand, and that there is not much oil at the factories. Reports from Maine are that the fishing is not very good, and the stock on hand about 1,000 bbls. They are reported to have made some sales to Boston at 37c., and one parcel of 250 bbls. sold at 38c., delivered in New Bedford.

JULY 19.

Menhaden oil has come to hand pretty freely of late, the Sound fishing having improved very much the past two weeks. The Maine fishing is also reported better, and their prices have been lowered to make sales. During the latter part of last week there were large arrivals from the Sound catch, in all some 1,200 bbls., and been placed, as nearly as we can trace them, as follows: 130 bbls. at 35c., 100 bbls. at 35c., 93 bbls. at 35½c., 60 bbls. at 35½c., 80 bbls. at 35½c., and 100 bbls. on private terms, all on spot; and to arrive here 200 bbls. at 35c., and in New Bedford 600 Maine, delivered there at 35c., the buyer's price and 36c. the seller's price.

JULY 26.

Menhaden oil became weaker following our last, as sellers continued to offer and buyers had a supply, and the market went down to 34c., with a sale at this price; but, though other goods were offered at this, buyers would not take them, and there was a lot placed at 33c., and to-day we hear that 32½c. was accepted for good brown oil. The sales made foot up 600 bbls.

AUGUST 2.

Menhaden oil has not come to hand in any quantity the past week, but, owing to the fact that most of the dealers are well stocked up, they are not anxious buyers, and the price has not improved. The reports from the fishermen is that there have been but few taken, and they yield a very small quantity of oil. There has been one sale of 100 bbls. at 33c., but lots can be had at 32½c., with no buyers at better than 32c. for ordinary quality.

AUGUST 9.

Menhaden oil is dull; dealers, being stocked, are not anxious to buy; and, though the fishing is reported as being very poor, no advance can be obtained. A choice lot of 290 bbls. sold at 33c., but an ordinary parcel could have been bought at 32c., and, not meeting with sale, was put into store.

AUGUST 16.

Menhaden oil has not come to hand very freely, but the supply is equal to the demand, as dealers have a stock and do not care to buy large lots except at a low price. There has been a shipment of 1,000 bbls. Maine, oil sold at 34c., and 400 bbls. Sound oil, part for shipment, at 32 @ 33c.

AUGUST 23.

Menhaden oil has not come to hand to any extent the past week, and the sales are of only two parcels, in all about 400 bbls., for export, at 32c. for Sound make and 33c. for Maine make. The reports from the Long Island coast is that the fish are quite plenty, but the yield of oil is so small, that there is an actual loss in the business. The Maine fishing is very good, the fish being ordinarily fat. There are offers to sell brown oil here at 32 @ 33c., but dealers are not anxious buyers, but want a light-colored oil, for which they are willing to pay the highest figure. There are exporters willing to pay 32c. for Maine oil, but though there may be a disposition on the part of the Eastern makers to accept this price, there is a good deal of difficulty in obtaining a vessel to take freight direct from a Maine port. Unless there can be some sales made for shipment, there will probably be a surplus on our market all year, with no probability of an advance.

AUGUST 30.

Menhaden oil has been quiet, with moderate arrivals. Buyers will pay 33c. @ 34c. for a light-colored lot, but most of them have a supply of dark colored, and are not willing to pay so much. There were sales of 400 bbls. at 33 @ 34c. and 75 bbls. on private terms.

SEPTEMBER 6.

Menhaden oil has not come to hand very freely, and the market is rather stronger for light-colored oil. The trade will pay 34c. for good, light, sweet oil. The sales are, 100 bbls. at 33c., 80 bbls. at 33c., 200 bbls. at 34c., 49 bbls. at 34c., and 60 bbls., irregular quality, at 34c. for prime.

SEPTEMBER 13.

Menhaden oil.—The market continues firm for this article, and holders are asking 34 @ 35c. for a prime article, but we note sales of 400 bbls., at 33 @ 34c. The Sound catch has been light, and the prevailing price for this product has been 32 @ 33c. from brown to light, but holders are asking an advance on Sound makes, 34c. for brown and 34 @ 35c. for light. The Maine catch of fish is mostly over, and the catch has been very fair as to quality and excellent as to quantity, but still not up to former seasons as regards quantity. Dealers and manufacturers, especially in Boston, have bought more freely of Maine oils than other makes. The present price for Boston, New Bedford, and New York delivery is 35c. The stock at New Bedford is reported small, with a small account held back by fishermen for higher prices. The future of this market is, however, uncertain, as there remains yet two months for fishing from Maine to south side of Long Island, and the conclusion is that prices will depend on this future catch, and it is doubted if exporters can take any considerable quantity if prices advance too far.

SEPTEMBER 20.

Menhaden oil.—The market remains steady and without change as regards prices since our last. The eastern catch is now about over, yet the fishermen are still hauling up the fish, and the balance of the catch is very uncertain, depending entirely upon the weather; and 33 @ 35c. is likely to be the ruling prices for at least the balance of September. There is little or no oil in first hands in this market. We note sales of 600 barrels Maine oil at 34c.

SEPTEMBER 27.

Menhaden oil.—The sales for the past week have been only in a jobbing way (if at all), and prices remain about as last reported. The weather for the past week has been unfavorable for the fishermen, and the main gangs have laid up, while the Long Island fishing is poor. Sales of a parcel of rejections have been made at 30c., but holders seem firm in their views at 34 @ 35c. for prime oil. We note sales of 1,690 bbls. bleached at 44½ @ 46½c. cash.

OCTOBER 4.

Menhaden oils have been very quiet here, as there have been no arrivals here of any account, and the market is nominally firm. The only sales are 100 bbls., at 35c. for prime and 30c. for inferior, and 100 bbls. inferior at 30 @ 31c.

Thus far the Sound fishing has been a failure, but they are expecting the fat large fish which have been so plenty in Maine to come to the Sound yet. The fish they are now taking are very small and yield no oil. The Maine fishing has been splendid, and one oil manufacturer is said to have made 10,000 bbls. of oil.

OCTOBER 11.

Menhaden oil is higher, as the fishing in the Sound has not improved.

One fisherman reports having taken only 5 bbls. from 400,000 fish. There are no offerings of any account, and good oil is wanted at 38c., and a choice lot might bring 40c., as the stock in the hands of dealers is small.

There have been no sales here this week that we learn of, but last week 100 bbls. brown sold at 35c., 700 bbls. fair at 35c., and 36 bbls. prime at 37c.

OCTOBER 18.

Menhaden oil is scarce and higher, as there have been no arrivals. The supply here is mostly in a few dealers' hands, and there is said to be very little oil left on Long Island Sound, but we also hear that the catch is better in Narragansett than at any time this year, and one maker took 400 bbls. of oil in the last ten days. The price will probably rule firm, however, as the fishing can hardly last long enough to get more than is actually wanted, and should there not be a continuance of the good fishing there may be an actual scarcity, which would result in very high prices. At the close, spot oil will bring very high prices, and one party holds good crude at 45c., with a sale of 200 bbls at 42c. The large movement in the East will advance prices there also. The past two days have been too windy for taking fish, and several gangs of fishermen have hauled up. The only sales here are 200 bbls. from second hand at 38@40c., the latter price paid at the close. We also heard of 250 bbls. Sound oil to arrive, and the make for the balance of the season of the two largest concerns to a dealer at a private price.

OCTOBER 25.

Menhaden oil is firm and active, and advanced prices are likely to be established unless the present fine weather should continue, which will enable the fishermen to make a month's catch yet, which will likely give a supply sufficient for the wants of the trade, yet the advance in whale-oil may so affect the market as to counteract the coming catch, and thereby cause prices to go still higher. We hear of recent purchases of 300 bbls. of Sound oil which have been put in store at a private price, but probably at 40c.; holders are now asking 45c. here, and we hear of no sales at less than 42c. for a prime article.

NOVEMBER 1.

Menhaden oil is hardly so strong in price as two weeks ago, as the catch in the Sound and Narragansett Bay has improved considerably; at the former place fish are plenty and fat, yielding a choice oil. There will, however, be no material decline in prices, unless the make should be very large, as the supply in the hands of dealers is not sufficient to carry them through the season, and there are said to be export orders at 42½c. The sales since our last are 350 bbls., Barren Island make, to arrive, at or about 42c. There were arrivals of 400 bbls., which had been sold some ten days or more, at 40c. Pressed oil has been sold in 25-bbl. lots at 45c.

NOVEMBER 8.

Menhaden oil is easier and lower since last week, on account of the

larger catch at Barren Island and Narragansett Bay. We hear at the close, however, that the fish are falling off and poorer, yielding only 5 to 6 gallons per thousand. We hear of sales of 650 bbls., ranging from 38 to 42½c., as to quality, with 40c. about the top price that any buyer would pay, and we hear that any bids made for round lots are much below this figure.

NOVEMBER 15.

Menhaden oil is fairly active, with the catch about over. There are only a few fishing gangs and two steamers on the Sound, and the Narragansett fishermen stopped last Saturday. The transactions foot up for the week some 750 bbls. at from 40 to 42c. for prime quality, closing firm, with the large holders asking the higher price. The Maine oil is held out of market.

NOVEMBER 22.

Menhaden oil is steady though not materially changed in price. The fishing season is now about over, and the supply to come forward cannot be great, and many parties look for an advance. The sales are 150 bbls. and 66 bbls., both a little off quality, at 40c.; 170 bbls. good at 41c., and 200 bbls. choice at 42c. The Maine oil in New Bedford is held out of market. Bleached is dull at 50c., light strained at 45@46c., bank at 44c., straits at 46c.

NOVEMBER 29.

Menhaden oil has ruled firm at an advance for very choice lots; other grades are quiet. The sales are 98 bbls. at 40c., 150 bbls. at 40c., 270 bbls. at 40½c., 165 bbls. at 41c., 100 bbls. at 42½c., and 150 bbls., very choice, at 43½c.

DECEMBER 6.

Menhaden oil is steady, but as trade is moderate the few parcels coming to hand will not bring any advance. There are some offerings at the close, but they are not large. The sales reported are 18 bbls. ordinary, at 40c.; 150 bbls., a mixed lot, light and brown, at 40c.; 160 bbls. choice, at 41c.; and 121 do., at 41c.; also, 180 bbls., at 40c. for brown, and 42 for selected.

DECEMBER 13.

Menhaden is quiet, with small sales and few arrivals. The sales reported are 240 bbls. prime Sound make, at 40½c., and 70 bbls. inferior, dark and strong, at 40c. The business done in pressed and bleached is rather light at about former prices.

DECEMBER 20.

Menhaden oil is very quiet, as arrivals are light, but still dealers would not be inclined to buy until after the new year. Holders ask 40@42c., with buyers willing to pay about 40@41c. Sales, 50 bbls. good Sound make, at 41c. There is a report that a sale was made of 400 bbls. Maine oil in New Bedford, at 44c., but we have not the report verified.

DECEMBER 27.

Menhaden oil is very quiet, as arrivals are light, but still dealers would not be inclined to buy until after the new year. Holders ask

41@42c., with buyers willing to pay about 40@41c. Sales of 50 bbls. prime Sound make, at 41c., and 60 bbls. light colored, a little off in quality, at 40½c. We are informed that a bid of 44c. from Boston has been refused for a large line of Maine make.

1877.

JANUARY 3.

Menhaden oil is very quiet, as arrivals are light, but still dealers would not be inclined to buy at any advance. Holders ask 41@43c., with buyers willing to pay about 40@42c. No sales reported. We have noticed that the annual meeting of the Menhaden Association will be held Jan. 10th, at New York.

JANUARY 10.

Menhaden oil has been quiet for some time past, and dealers would not take hold except at some concession in price, but this the holders were not inclined to grant, and there were few sales for several weeks past; but within a few days there were sales of 1,000 bbls. Maine make in New Bedford, to go to Boston, said to be off in quality, and we suppose the price not to be far off from 40c. In addition to this, 468 bbls. sold to come here, and 590 bbls. Sound make sold here; but we are requested to withhold terms. There was a lot of 150 bbls. offering within the past day or two, but was not sold that we hear of. The above transactions would indicate an easier market, but the advance in cotton-seed oils may cause a firmer tone.

JANUARY 17.

Menhaden oil is not changed, but is dull. Holders are, however, generally firm, and look for an improvement in price later on in the season.

JANUARY 24.

Menhaden oil has been very quiet, and there have been but few sales for several weeks past. Prices are maintained, as the stock is light. The only sales we hear of are 50 bbls. prime, at 42c., and 75 bbls. light pressed, at 46c.

JANUARY 31.

Menhaden oil remains nominal, as there are no arrivals, no demand, and no sales. The advance in cotton-seed oil, however, is expected to have an effect on these.

FEBRUARY 7.

Menhaden oil has not moved to any extent since our last, and prices have not improved. The only sale we hear of is a lot of 100 bbls. prime light at 45c. cash.

FEBRUARY 14.

Menhaden oil is dull and the price is quite nominal, as there has been no sales in the regular way for some time past. Buyers' ideas are 40 @ 41c. for good Sound oil, while sellers hold for 2 @ 3c. higher prices. It is reported that a Boston party has bid 45c. for a lot of Maine oil, and this was refused. Pressed and manufactured oils are not changed in price, but a small parcel of the former is said to have been sold low for cash.

FEBRUARY 21.

Menhaden oil still remains quiet, and we do not hear of much offering from first hands. Some of the smaller dealers are in small stock, and we heard that 150 bbls. very handsome late fall catch sold from second hands at 42c., and 78 bbls. do. at 42½c.

FEBRUARY 28.

Menhaden oil is a little more active, as the stock in the hands of some dealers is becoming light. Sales are 150 lbs. crude at 42c. on spot, and 180 bbls. to arrive at 41½ c., both for home use.

MARCH 7.

Menhaden oil has been offering more freely the past week, those having stocks being inclined to market them before the new season begins. Dealers are not willing to buy except at low prices, and we heard of sales of 100 bbls. Maine at 41c., and 159 bbls. Sound at 40c. Pressed and manufactured menhaden is easier, and we heard of 100 bbls. sold for export at 42½c.

MARCH 21.

Menhaden oil is dull and offering more freely, with buyers holding off and bidding 39c. Most sellers are firm, however, and one of the largest holders asks 45c. for Maine catch. The price is unsettled and nominal, and may advance or decline in the near future. The only transaction we hear of is 125 lbs. Maine at 41c. Pressed oil is offering low from Boston, but a special lot which can be had at 41c. laid down here is said to be off quality.

MARCH 21.

Menhaden oil is still quiet, but the stock is becoming reduced and chiefly in the hands of one party. One parcel of Maine has recently been closed out, though mostly reported by us before. There was in all some 850 bbls., and brought from 41 to 42c.

MARCH 28.

Menhaden oil continues quiet, though there is rather more inquiry, some for export, but, as a rule, limits are far below the market price. The only sales we hear of since our last are 70 bbls. for export at 41c., and 50 bbls. for home use at 41c.; both lots were Maine make. We also heard of a sale of 100 bbls. choice pressed at 43½c.

APRIL 4.

Menhaden oil has been very dull for some time past and is lower in price, good quality offering here at 40c. without finding buyers. There have been no sales here, but in New Bedford a sale of 500 bbls. dark-colored is reported sold to go to Boston at a private price. The manufactured fish-oils are in little better demand, but prices are easy.

APRIL 11.

Menhaden oils are easier, as those holding supplies of crude have been anxious to sell, and purchasers could be induced to take stock only by liberal concessions from holders. The trade generally have a suffi-

cient stock to supply their wants till new oil reaches market, but should the catch be later than usual there might be a week or more of scarcity; but dealers are generally willing to take their chances rather than buy at present. The sales reported are 307 bbls. on private terms. There was a lot, a little off quality, sold at 38c.

APRIL 18.

Menhaden oil has been weak and drooping for some time pas., and to sell low, prices would have to be accepted. There was an export demand but at a low price which has been accepted for 1,000 bbls. The terms are kept quiet, but a similar lot would probably not bring better than 35 @ 36c. We hear of a small lot of Southern new in market, but no price has yet been named for it.

APRIL 25.

Menhaden oil has been offering freely of late by parties who held stock over from last season in anticipation of higher prices this spring. The consuming trade have taken less than usual and prices were held too high all winter, and until recently, for exporters to make purchases. During the past two weeks, however, holders determined to make sales, and as it would not be taken at home, prices were named that met the views of shippers, and some 3,000 bbls. have been placed for shipment, said to have been at 35 & 38c.; this includes sales reported in last issue, since which we hear of 175 bbls. at 35c., 900 bbls. Maine at 38c., and 500 bbls. on private terms. The first new oil came in last week, a small lot of 11 bbls. Southern, and a little off in flavor; this was sold at 33½c., a full price.

MAY 2.

Manhaden oil was easy just previous to our last report and there were sellers at 35½c., but the following day buyers for export came into market and paid 37½c., delivered, for 500 bbls. A sale was then made for home use of 300 bbls. at 37c. and since 100 bbls. at same price. At the close there are further negotiations for export, but holders have advanced their views. A Long Island newspaper of last week contains the following item, which shows that fishing has commenced:

"Bunkers caught in the pounds, but not many yet. Cassidy Bros. at Asshamomoque took 3,000 one night. The purse-net gangs were out early in the week, but got no fish until Wednesday, when Capt. E. Tallman took 37,000 and Capt. Jas. Downs about 80,000 fish of very good quality, all of them being quite fat for so early in the season. Capt. Mart. Griffing also took 100,000 the same day."

MAY 9.

Menhaden oil has come to hand freely, and that of the new catch is unusually handsome. During the last week one commission merchant sold 1,000 bbls. for export as it arrives at 37 @ 38c. The recent sales reported are 100 bbls. new at 36c.; 25 bbls., 36c.; 250 bbls. old on private terms, said to be 38c. At the close there is not much offering, and the market is steady at 37c. A Greenport, L. I., journal of the 5th says:

"The season has opened this year more successfully than ever before. We gave a few figures last week of the first day's catch by some of the gangs on Gardiner's and Peconic Bays. On Friday and Saturday Capt. J. S. Biggs took 247,500, and on Monday he took 250,000. Capt. Mart. Griffing also made large hauls, but we did not get the precise figures; however, up to May 2d he was 'high hook," having taken about 670,000, while the next nearest catch was that of Capt. Talman, who had taken 635,000. On the 1st, seven steamers, including two from Connecticut and two from Rhode Island, were fishing in the bays."

MAY 16.

Menhaden oil is steady, as the export sales for the past few weeks have left no surplus on the market, and dealers are not very well supplied. The arrivals for the past week have not been large, and fishing is said to have fallen off a little. The sales reported are 20 bbls. dark at 36c., 200 bbls. prime at 37½c., 60 bbls. at 38c., and a small lot of Southern at 35c. A Greenport journal says:

"The catch of menhaden has been light this week. Unfavorable weather and the departure from the bays of the first 'run' of fish, have prevented most of the gangs from getting many. On Tuesday, Capt. Tallman, of stmr. E. F. Price, took 150,000 in the ocean off Easthampton."

A Sag Harbor journal of the 10th says:

"During the last two weeks the bunker or menhaden fishery has been very brisk, exceeding that of any previous season of late, both as to the fatness of the first run and as to the time of striking on the coast, the fish coming into our waters some two weeks earlier than usual, and making four to five gallons of oil to the thousand. During last week the Sterling Oil-Works at Cedar Point took in 800,000 fish, and in three days of the same week Wells's factory took 1,000,000."

MAY 23.

Menhaden oil is not coming to hand very freely, as the catch of late has not been very good, and most of the new had been sold before for shipment. The old stock is about closed out. The sales reported are 900 bbls. old and 300 bbls. new, for shipment at 37 @ 37½c. 50 bbls. new at 36c., and 75 bbls. at 35 @ 37c.

MAY 30.

Menhaden oil is rather easier at the close. The catch has been fair, but the export orders had been mostly filled, and the lots are now coming on the home markets. The sales reported are 160 bbls. at 37c., 110 bbls. at 36½c., and 70 bbls. at 36c., with sellers at the close at this price.

JUNE 6.

Menhaden oil has been more plenty and prices have declined as home buyers were getting full supplies and exporters not taking. The market closes quiet. The sales since our last are 70 bbls. at 36½c., 90 bbls. at 36c., 80 bbls. at 35c., and 250 bbls. at 34c.

JUNE 13.

Menhaden oil has settled down to 34c., at which price there has been a good trade doing, and the market seems steady with the following parcels placed: 400 bbls. at 35c., 150 bbls. at 34c., 75 bbls. at 34c., 50 bbls. at 34c., 94 bbls. at 34c., 62 bbls. at 34c., and 110 bbls. at 34c.

JUNE 20.

Menhaden oil has come to hand quite freely, but prime quality has ruled steady at 34c., though some off-grade was offered to-day at 33c. The sales reported for the week are 250 bbls. at 34c., 80 bbls. at 34c., 96 bbls. at 34c., and 156 bbls. at 33½c. Light strained oil can be had at 38c., bank at 39c., and straits at 40c.

JUNE 27.

Menhaden oil has come to hand quite freely, but a good deal had been sold before, a small part for export. The market is steady, with buyers at 33c., but it would be difficult to get a much higher price for a round lot. The sales reported are 300 bbls. at 33c., 156 bbls. at 33c., 67 bbls. at 33c., and 50 bbls. at 33½c. We also hear of 200 bbls. in New Bedford on private terms. We print an item below which would show that the catch is large, but we hear since by letter that the fish are running poor, and the oil from them dark.

"For the first time this season some considerable numbers of menhaden were taken in Gardiner's and Peconic Bays last week. On Monday Capt. E. Tallman took 64,000 in the lower bay; and again on Friday, after taking 150,000 at two dips in the ocean to the southward of Amagansett, in coming up to the factory he got 60,000 from them, making his day's catch 210,000. Capt. Israel Warner also made several good hauls of fish in the upper bay, the first we have heard of in that vicinity. While the quantity of fish in the outer ocean has been practically limitless, and every gang who could go outside to get them has been able on every fair day to make good catches, by a remarkable departure from the usual fact heretofore, few or no fish have entered the bays. Indeed, it is asserted that of all those so far rendered into oil and guano at the factories on shore, or in its limits, not one million in all have been caught in the bay. Opinions differ as to the cause or causes of this result, but the general belief is that the presence of food has been the determining element in the question. Food has been and continues abundant in the ocean, hence the fish stay outside. Except for a few days of thick fog the weather has been quite favorable, and many fish continue to be taken.

"Greenport, L. I., June 23."

JULY 4.

Menhaden oil has ruled steady, with no great surplus offering, the arrivals being moderate, and some lots taken for export. The sales reported are 250 bbls. at 32½c., 75 bbls. at 32½c. for home use, and 200 bbls. at 33c., free on board for export.

"Steamer E. S. Newins, Capt. J. W. Hawkins, was in port on Wednes-

day. On Tuesday she took 125,000 menhaden in the ocean off Quogue, and reports immense bodies of the fish at that place. It is also reported that the shore seines along the Hamptons have been taking great quantities of the fish lately. The advantage of employing steamers is shown strongly in the fact that the Newins on her Tuesday trip out and back traveled about 150 miles, a distance quite out of the question for sailing vessels."—Long Island Journal, June 30, 1877.

JULY 11.

Menhaden oil is not coming on the market in large lots, as a good deal of the arrivals are going on shipboard. The different sales for home use that we hear of are 78 bbls. at 32½c., 60 bbls. at 32½c., 80 bbls. at 32½c., 46 bbls. at 32½c., and 71 bbls. at 32½c.

JULY 18, 1877.

Menhaden oil came to hand sparingly last week, the fishing both in the Sound and on the coast of Maine having been poor for some time past. The reports to-day are, however, more favorable. The market has been steady, but not active; no export orders at the moment. The sales reported are 150 bbls. at 32½c., 58 bbls. at 33c.; and a lot of 100 bbls. good, fair quality was offering to-day at the latter price.

The total exports from the United States, from January to June 30th, were 11,010 bbls.

JULY 25.

Menhaden is in small demand for home use. The arrivals are light, but fully up to the wants of the trade. Prices are steady, with sales of 110 bbls. at 32½c., and 64 bbls. at 33c.

AUGUST 1.

Menhaden oil has not come to hand since our last, and the receipts during July are probably as small as we ever knew them. The demand here is not large, however, and we do not know that better than 32½ @ 33c. would be paid. The catch in the Sound is only fair, and the Maine fishing thus far quite poor. The Boston market is poorly supplied, and are bidding 34c., delivered, with sales of several lots at the Connecticut factories at 32½ @ 33c.

AUGUST 8.

Menhaden oil is very much stronger here, though not much higher on actual business. The Maine catch being light, New Bedford and Boston dealers have had to go direct to the Long Island and Sound factories and buy, and we hear that they have bought at 32½ @ 33½c. at the factory, equal to 35c. delivered. In consequence of these sales we have had very little oil here, and these lots are promptly taken on arrival. The sales reported are 200 bbls. Barren Island at 33½c., and two lots of 50 bbls. each at 33c.

AUGUST 15.

Menhaden oil has not come to this market to any extent of late, and the price is higher. There have been few sales for want of stock. We heard that 175 bbls. were placed at 34 @ 34½c., with 35c. now bid, and possibly 36c. will be paid. Sales are reported in the East as high as 40c. Bleached oil is higher also, as well as all the other grades.

AUGUST 22.

Menhaden oil is not coming in, and the price is very much higher, with one sale of 100 bbls. prime at 36c., with other sales of 250 bbls. reported at 35c., which price will now be paid.

AUGUST 29.

Menhaden oil scarce and higher, with exceedingly small arrivals, the Maine fishery being very poor, and Eastern dealers drawing their supplies from the Sound catch. We are receiving very little here, and our dealers are short of stock. The sales reported since our last are 128 bbls. brown at 36c., and 75 bbls. select light at 38c. Strained and bleached are higher.

SEPTEMBER 5.

Menhaden oil is scarce, and higher prices would be paid for lots, but there are none arriving. It is difficult to say what could be obtained, but probably 38c., though some dealers say they would not pay more than 35c. If the present scarcity continues prices will go above 40c very soon.

SEPTEMBER 12.

Eastern buyers are visiting the Long Island Sound factories, picking up all the menhaden oil they can find. Makers are, however, generally holding for higher prices, expecting to get 45c. soon. One lot has been sold equivalent to 42c. delivered.

SEPTEMBER 19.

Menhaden oil is scarce here, and there are no sales for want of stock; prices are nominal, but a lot would probably bring somewhere near 45c. if nice. We hear that 500 bbls. sold in New Bedford at 45c. cash, and 300 bbls. at works on Long Isl'd at 43c. Bleached oils are higher, and 250 bbls. sold at 50c.

SEPTEMBER 26.

Menhaden oil is not to be had, and though a higher price would be paid, we do not know what it would be. It is hoped that fishing will yet be good before cold weather sets in. There has been a good demand for bleached, which is now higher also; sales were made of 100 bbls. at 51c., and 50 bbls. at 52c.

OCTOBER 3.

Menhaden oil is still very firm, and the lots coming in are readily taken at high prices. The last catch of fish at Maine was good, but all except two factories were closed, and the make was consequently small. The fishermen are now at Provincetown, awaiting the fish as they go down the coast. It is hoped that the catch may yet be good, but it cannot make up the deficiency. The sales reported here are 215 bbls. at 44c., 100 bbls. at 44c., 100 bbls. resold at 44c., and 120 bbls. at 44c. cash; in New Bedford, 300 bbls. Maine at 45c., 250 bbls. at 45c., and 100 bbls. at 45c. Bleached is firmer and in good demand, with sales of 250 bbls. here at 52c.

OCTOBER 10.

Menhaden oil is still in limited supply and firm in price, though we are reported sales by one party of 300 bbls. at 43 @ 44c. We know, how-

ever, of sales of 150 bbls. here at 44c., and hear that there has been some business done in the East at 47c.

A letter from New Haven, dated October 8, 1877, says: "The stormy weather of a portion of last week reduced what would have been a small catch of menhaden anyway to a very meagre amount. They ran one grade better than previously, and it is hoped a radical change of quality is very near. Fishermen in the usual quality of their 'devotions' are praying for quiet weather."

OCTOBER 17.

Menhaden oil still rules very firm with few lots to be had. There have been some sales of Sound made at 44 @ 45c., with none offering at the close that we hear of. In reference to the catch we have the following under date of October 15, 1877:

"There were but two fishing days last week on Long Island Sound, owing to winds. The catch was good as to quantity, but still poor in quality. The season lasts but about a month longer, and impatience is felt for the appearance of fat fish."

OCTOBER 24.

Menhaden has come to hand more freely the past week than at any time this season, and indirectly we hear that fishing at Provincetown and vicinity is good; that several of the Maine factories are running on the fish their boats catch there, and that there is a possibility of the deficiency being yet nearly made up, the fish being very fat. The stocks here in the hands of dealers are very light, but they also report a very moderate demand, tanners using cod, degras, and other greases in place of menhaden. There is a cargo of 600 bbls. of Maine oil in, a part of which is reported sold to a dealer at 46c., and sales are said to have been made in New Bedford at as high as 47c. There were sales here, however, of prime light Sound make of 100 bbls. on spot at 45c., and 100 bbls. to arrive at 45c., with the close easy. Bleached is easy, and we do not hear of any late sales; holders ask 52 @ 52½c.

From New Haven, October 20, 1877, a correspondent says:

"We do not hear that a menhaden has been caught this week anywhere west of Massachusetts. It is hoped to be the interval between the change of plays, where the farce ends and the solid piece begins. Fat fish are now looked for daily."

OCTOBER 31, 1877.

Menhaden has been quiet the past week, the lots coming in having mostly been placed before arrival. We only hear of a lot of 75 bbls. choice, which brought 45c., and other lots are offering at this figure.

NOVEMBER 7.

Menhaden oil has been offering more freely, and with buyers' ideas a little lower. Sales have been made of 500 bbls. at 44 @ 45c. Bleached winter is quoted higher by some parties, but can still be had at 52½ @ 53c. Bank and Straits are steady.

NOVEMBER 14, 1877.

Menhaden oil has been in fair request during the past week and par-

cels have been taken at previous figures, and we hear of sales of 250 bbls. Sound oil at 44½ @ 45c., 116 bbls. at 44½c., 500 bbls. at 45c., and 250 bbls. at 44 @ 45c. The close is rather quiet, as but few lots are offering. Bleached is held at 53 @ 54c., with sales of 50 bbls. at 53c. Banks and Straits quiet and steady at 48 @ 50c.

A correspondent from New Haven, under date of November 12, says: "Fat menhaden were caught the first week in this month, but owing to the strong winds and stormy weather the aggregate was quite small. Last week gave but a small quantity and they were quite poor, about 1½ gall. to the thousand. This week will close most of the fishing unless there is a change in quantity and quality. The fishermen are greatly disappointed in the result of their fall work."

NOVEMBER 21.

Menhaden is strong, as the catch is now said to be about over. There have been sales of 300 bbls. crude at 44½ @ 45c. Bleached is jobbing at 53c., and a lot of 50 bbls. sold at this price, 60 days' time.

NOVEMBER 28.

Menhaden is firm, and prime light oil on spot will bring 45c., at which price we heard of a sale of 100 bbls.; also 228 bbls. to arrive at 44¾c., and 78 bbls. brown, on spot, at 44½c. Bleached is in fair demand, with prices ruling about steady; 60 bbls. sold at 53c., 60 days.

DECEMRER 5.

Menhaden oil has ruled very firm, and there has been a good demand, with stocks in the hands of the dealers not large. The sales reported are 500 bbls. at 45c., 250 bbls. at 45c., and 280 bbls. dark at 44c. Bleached winter is selling fairly, and we note 150 bbls., at 52½c., with some now asking an advance.

DECEMBER 12.

Menhaden oil is steady, but very quiet. The offerings are moderate, but buyers are not wanting any, except very choice of the last catch. We do not hear of any sales; prime would bring 45 @ 45½c., and choice light-colored 46 @ 46½c. Bleached is steady and in demand, with 100 bbls. reported sold at 52½c. cash. Bank and Straits are in light demand at former prices.

DECEMBER 19.

Menhaden oil is firm, and the lots coming to hand are readily taken. There was a cargo in last week, about 500 bbls., 150 bbls. of which sold at 44 @ 45c., 100 bbls. were delivered on a contract made early last summer at 33c., and the balance went into store. Bleached sold last week at 52½c.

DECEMBER 26.

Menhaden oil has been rather quiet, with a few lots coming in. We heard of a sale of 128 bbls. at 44c., but the price generally quoted is 45c. Bleached is steady, with a sale of 50 bbls. reported at 52½c.

JANUARY 2, 1878.

Menhaden oil has not sold since our last report that we hear of. A lot could not have been sold at its real value. We understand that 45c. is about the price dealers have marked their stock in taking account.

APPENDIX L.

Annual proceedings of the United States Menhaden Oil and Guano Association.

FIRST ANNUAL MEETING.

At a meeting of the menhaden oil and fish guano manufacturers of Maine, Long Island, Connecticut, Rhode Island, and New Jersey, held in New York January 7, an association was formed, to be known as "The United States Menhaden Oil and Guano Association." A constitution and articles of association were adopted.

The meeting organized with R. L. Fowler of Guilford, Conn., as chairman, and Luther Maddocks, of Booth Bay, Me., as secretary. After some discussion a committee on statistics was appointed, with instructions to report as soon as possible. The committee was as follows: Mr. L. Maddocks, Maine; Mr. Church, from Rhode Island; Mr. Price, from Long Island; and Mr. Fairchild, from Connecticut.

Mr. Fairchild, as chairman, reported as follows: Number of factories in operation, 62; amount of capital invested, $2,388,000; number of fishermen employed, 1,197; number of men employed at factories, 1,109; number of sailing-vessels employed, 383; number of steamers employed, 20; total number of fish caught, 1,193,100 barrels (250 fish to barrel); total of oil made, 2,214,800 gallons; total amount of guano made, 36,299 tons. Stock in hand of manufacturers, 484,520 gallons oil and 2,700 tons guano.

The meeting then voted to appoint a committee on permanent organization and to report a constitution and by-laws. This committee consisted of Mr. J. G. Nickerson, Boston; Mr. Thomas F. Price, Greenport, Long Island, and Mr. H. L. Dudley, New Haven. Their report was accepted and the constitution adopted, and the following officers chosen for the ensuing year: President, Luther Maddocks, of Booth Bay, Me.; vice-presidents, George F. Tuthill, Greenport, Long Island, and R. L. Fowler, Guilford, Conn.; secretary and treasurer, H. L. Dudley, New Haven; executive committee, Luther Maddocks, Booth Bay, Me., David F. Vail, River-head, Long Island, B. F. Brightman, Round Pond, Me.

Constitution and by-laws of the United States Menhaden Oil and Guano Association.

NEW YORK, *January* 7, 1874.

Whereas the manufacture of menhaden oil and fish guano has become identified as one of the important industries of this country; therefore

Resolved, That we, the manufacturers, with the view of rendering to each other mutual aid and assistance, do hereby form ourselves into an association for this purpose, and to be governed by the following constitution:

ARTICLE 1. This association shall be called the "United States Menhaden Oil and Guano Association."

ART. 2. The officers shall be a president, two vice-presidents, secretary and treasurer, and executive committee.

ART. 3. the president shall preside at all meetings of the association. In the absence of the president either of the vice-presidents may preside. In the absence of all these officers a president shall be chosen *pro tem.*

ART. 4. The secretary shall keep a faithful record of all buisness transacted at each meeting of the society, and shall notify members of all meetings by written or printed notice.

ART. 5. The treasurer shall have charge of all funds belonging to the association, and shall pay them out only by order of the executive committee.

ART. 6. The executive committee shall consist of three, of which the president shall be one. They shall have power to raise money to meet the expenses of the association by an equitable assessment of each member, and shall have a general supervision of all the affairs and business of the association not otherwise provided for.

ART. 7. The annual meeting of this association shall be held on the 2d Wednesday of January annually. The place of meeting shall be determined by a majority of the executive committee, and a notice shall be mailed by the secretary to each member of the association fifteen days previous to the time of meeting.

ART. 8. Special meetings of the association may be called at any time by the executive committee, and upon a written request signed by five members addressed to the president. Notice of all such meetings shall be mailed by the secretary to each member ten days previous to the time of meeting.

ART. 9. Any person, or any member of any company, engaged in the manufacture of menhaden oil and fish guano in the United States may become a member of the association by subscribing to this constitution and these articles of association.

ART. 10. Each firm or company shall be entitled to but one vote at meetings of the association.

ART. 11. The officers of this association shall be chosen annually by ballot, and shall hold their office for one year or until others are chosen.

ART. 12. This constitution may be amended at any annual meeting, or special meeting called for that purpose, by a two-thirds vote of the members present.

ART. 13. Nine members shall constitute a quorum, but a less number may adjourn.

SECOND ANNUAL MEETING—1874.

The report of the statistical committee was as follows:

Number of factories in operation	64
Number of men employed at factories	871
Number of sail vessels	283
Number of steamers	25

Number of men employed in fishing	1,567
Amount of capital invested	$2,500,000
Number of fish caught	492,878,000
Estimated in barrels	1,478,634
Tons of guano made	50,976
Gallons of oil made	3,372,837
Guano on hand January 13, 1875 ... tons	5,200
Oil on hand January 13, 1875 ... gallons	*648,000

THIRD ANNUAL MEETING—1875.

The third annual meeting of this association was held at the Aldrich House, Providence, R. I., January 12, 1876. The following-named manufacturers were present: R. L. Fowler, Connecticut; L. Maddocks, Maine; F. E. Colburn, Connecticut; E. T. Dublois, Rhode Island; George W. Miles, Connecticut; B. F. Brightman, Maine; Daniel T. Church, Rhode Island; William J. Brightman, Rhode Island; Isaac Brown, Rhode Island; John Southworth, Rhode Island; Frederick Gallup, Connecticut; B. F. Gallup, Connecticut; S. Jones, New York; V. Koon & Son, New York; J. H. Bishop, Connecticut, William Holmes, Connecticut; Job T. Wilson, Massachusetts; H. L. Dudley, Connecticut.

The president, R. L. Fowler, being in the chair, the minutes of the last meeting were read and approved.

The treasurer's report was read, examined, and accepted.

The committee on statistics reported as follows:

Number of factories in operation in 1874	64
Number of factories in operation in 1875	60
Decrease	4
Number of men employed in 1874	2,438
Number of men employed in 1875	2,633
Increase	195
Number of sailing-vessels employed in 1874	283
Number of sailing-vessels employed in 1875	304
Increase	21
Number of steam-vessels employed in 1874	25
Number of steam-vessels employed in 1875	39
Increase	14

* The full records of this meeting were not to be obtained.

Number of fish caught in 1874	492,878,000, or 1,642,927 barrels.
Number of fish caught in 1875	563,327,000, or 1,877,767 barrels.
Increase	70,449,000, or 734,840 barrels.

Number of gallons of oil made in 1874	3,372,847
Number of gallons of oil made in 1875	2,681,487
Decrease	691,360
Number of tons of guano made in 1874	50,976
Number of tons of guano made in 1875	53,625
Increase	2,649
Amount of capital invested in 1875	$2,500,000
Amount of capital invested in 1876	2,650,000
Increase	150,000
Number of gallons of oil held by manufacturers January 12, 1875	648,000
Number of gallons of oil held by manufacturers January 12, 1876	125,000
Number of gallons in manfacturers' hands less than at annual meeting in 1875	523,000
Number of tons guano held by manufacturers January 12, 1875	5,200
Number of tons guano held by manufacturers January 12, 1876	1,850
Number of tons guano held by manufacturers, less than in 1875	3,350

The following officers were elected for the ensuing year: President, R. L. Fowler, Guilford, Conn.; first vice-president, B. Frank Gallup, Groton, Conn.; second vice-president, Daniel T. Church, Tiverton, R. I.; secretary and treasurer, H. L. Dudley, New Haven, Conn.; executive committee, R. L. Fowler, Connecticut, V. Koon, New York, Isaac Brown, Rhode Island.

A letter from the Hon. S. L. Goodale, of Saco, Me., was presented to the association by Mr. Maddocks, and read by the secretary. It was listened to with much pleasure and interest, and the secretary was directed to incorporate the substance of the letter in his report. It stated that the writer had discovered a process for making, from the juices of

the menhaden, an extract similar to the article now so extensively manufactured and sold as "extract of beef," and that the juices of the menhaden were better for this purpose than those of any other fish yet tested. Mr. Goodale is confident that "now, for the first time, is the true function of this fish in the economy of nature recognized," and that the time is not far distant when the *principal* product sought for from it will be its concentrated juices, while the quantity of oil and scrap obtained will not be noticeably diminished, as this process utilizes that portion of the fish which has formerly been, and by the present mode of manufacture is still, allowed to go to waste. In support of his discovery, Mr. Goodale quotes from a letter received from that eminent and reliable chemist, Prof. Samuel W. Johnson, of Yale College, as follows: "I cannot doubt that the fish extract is entirely new, and, as food, is equal to beef extract in all respects (except, possibly, in the matter of iron), and, if put into the market in proper shape, would shortly share the patronage now so largely bestowed on beef extract." It is hoped that some practical test of this discovery will soon be made.

Some interesting facts and figures were presented by Messrs. Maddocks, Brightman, and Church, upon the shrinkage of fish during the process of manufacture, and in the difference in yield of scrap from the same number of fish at different factories.

An article was read from the New York Commercial Bulletin giving some facts concerning the foreign and domestic trade in fish scrap. Some four thousand tons of scrap were stated to have been recently shipped to Liverpool and Queenstown, as the result of some experimental shipments made last year. There is also a growing demand in the West Indies. It is evident that both the foreign and domestic demand for fish scrap is rapidly increasing.

The following resolution was freely discussed and unanimously passed:

"*Resolved*, That all guano or scrap manufactured by members of this association shall be sold at the weight taken at the factory of the seller."

Particular attention is called to the above resolution, as it is a matter of no little importance whether the scrap is weighed at the place of shipment or place of delivery, and there is no doubt the buyers of scrap will see the justice of this resolution and readily accede to it. All present pledged themselves to rigidly adhere to the resolution.

An adjourned meeting of the association will be held at the Aldrich House, Providence, R. I., on Wednesday, April 5, 1876, at 10 o'clock a. m.

H. L. DUDLEY, *Secretary.*

NEW HAVEN, *January* 15, 1876.

FOURTH ANNUAL MEETING.

The fourth annual meeting of this association was held at the United States Hotel, New York, January 10, 1877, the president, R. L. Fowler, in the chair. The minutes of the last meeting were read and accepted; the treasurer's report was read and accepted; the committee on statistics reported as follows:

Number of factories in operation in 1876	64
Number of factories in operation in 1875	60
Gain	4
Number of sail-vessels employed in 1876	320
Number of sail-vessels employed in 1875	304
Gain	16
Number of steam-vessels employed in 1876	46
Number of steam-vessels employed in 1875	39
Gain	7
Number of men employed in 1876	2,758
Number of men employed in 1875	2,633
Gain	125
Amount of capital invested in 1876	$2,750,000
Amount of capital invested in 1875	2,650,000
Gain	100,000
Number of fish caught in 1876	512,450,000
Number of fish caught in 1875	563,327,000
Loss	50,877,000
Estimated by barrels in 1876	1,535,885
Estimated by barrels in 1875	1,877,767
Loss	341,882
Number of gallons of oil made in 1876	2,992,000
Number of gallons of oil made in 1875	2,681,487
Gain	310,513

Number of tons of guano made in 1876	51,245
Number of tons of guano made in 1875	53,625
Loss	2,380
Number of gallons of oil held by manufacturers January 10, 1877	264,000
Number of gallons of oil held by manufacturers January 12, 1876	*125,000
In excess of amount held January, 1876	139,000
Number of tons of guano held by manufacturers January 10, 1877	7,275
Number of tons of guano held by manufacturers January 12, 1876	5,200
In excess of amount held January 12, 1876	2,075

The report of the committee on statistics was accepted. This report is believed to be the most accurate and full of any yet obtained by the association, and the committee are much indebted to Mr. Jasper Pryer for information received and assistance rendered. The officers were chosen for the ensuing year by ballott, and were as follows: President, R. L. Fowler, Guilford, Conn.; first vice-president, Daniel T. Church, Tiverton, R. I.; second vice-president, B. Frank Gallup, Groton, Conn.; secretary and treasurer, H. L. Dudley, New Haven, Conn.; executive committee, R. L. Fowler, Guilford, Conn., George F. Tuthill, Greenport, N. Y., B. F. Brightman, Round Pond, Me.

Application for admission as members was made by persons not manufacturers of, but dealers in, oil and guano. After some discussion it was decided to postpone any action upon the matter until the next annual meeting, notice of which is to be given to the applicants by the secretary. Hon. S. L. Goodale, of Saco, Me., made an address upon the food properties of the menhaden, and produced samples of an extract obtained from menhaden, which has been pronounced by the most eminent scientific authorities quite equal in nutritious properties to the well-known beef extract. The menhaden extract was sampled by the association, and not unfavorably compared with the beef extract, a sample of which was also on trial. It is hoped that the successful development of this new branch of the menhaden industry is not far distant. A vote of thanks was given Mr. Goodale for his address.

* N. B.—In the estimate of oil held by manufacturers, January 12, 1876, oil at New Bedford was not included, therefore the stock held January, 1877, by manufacturers, is about the same as that of January, 1876; but it was deemed best to include in this and future reports all oil held by manufacturers, or for their account, and thus present a full report of all the oil unsold, or to be put into market, by manufacturers.

Encouraging statements in regard to foreign demand for fish guano were made by Mr. Pryer, representing Messrs. Jed. Frye & Co., shipments having been made to Europe by this firm during the past season. More attention is being given to the drying of the fish scrap, as in that form all of our product may be exported at fair prices. A communication from a gentleman engaged in foreign trade was read by Mr. George F. Tuthill, stating that 30,000 tons of the dried fish scrap could be sold annually in Italy, and parties were ready to make contracts for full cargoes. It is probable that a large quantity will be sent abroad the coming season.

After some discussion upon fixing a time and place for the next meeting, a vote was passed amending article 7 of the constitution. As amended the article reads as follows: "Article 7. The annual meeting of this association shall be held in January, annually, and the time and place of meeting shall be determined by a majority of the executive committee, and a notice shall be mailed by the secretary to each member of this association fifteen days previous to the time of meeting." As the meeting of the Maine association was held in Boston the day before our meeting, our attendance was small. Another year, probably, the time and place of meeting of this association will be arranged to suit the convenience of a large number of its members.

H. L. DUDLEY, *Secretary.*

FIFTH ANNUAL MEETING.

The fifth annual meeting of this association was held at the City Hotel, Providence, R. I., January 9, 1878, the president, R. L. Fowler, in the chair. In the absence of the secretary, Luther Maddocks, esq., was appointed secretary *pro tempore.*

The minutes of the last meeting were read and approved. Treasurer's report read and accepted. The officers elected for the ensuing year were: President, R. L. Fowler, Guilford, Conn.; first vice-president, Daniel T. Church, Tiverton, R. I.; second vice-president, B. Frank Gallup, Groton, Conn.; secretary and treasurer, H. L. Dudley, New Haven, Conn.; executive committee, R. L. Fowler, Guilford, Conn., Isaac Brown, Tiverton, R. I., George W. Miles, Milford, Conn.

Voted, To assess each member one dollar, the same to be collected by the treasurer.

Isaac Brown, The Narragansett Oil Company, and J. G. White were admitted to membership in the association.

Voted, That the next annual meeting of the association be held in New York City.

Voted, That any firm or company belonging to the association may be represented at its meetings by proxy.

The committee on statistics reported as follows:

Number of factories in operation in 1876	64
Number of factories in operation in 1877	56
Loss	8
Number of sail-vessels employed in 1876	320
Number of sail-vessels employed in 1877	270
Loss	50
Number of steam-vessels employed in 1876	46
Number of steam-vessels employed in 1877	63
Gain	17
Number of men employed in 1876	2,758
Number of men employed in 1877	2,631
Loss	127
Amount of capital invested in 1876	$2,750,000
Amount of capital invested in 1877	2,047,612
Loss	*$702,388
Number of fish caught in 1876	512,450,000
Number of fish caught in 1877	587,624,125
Gain	75,174,125
Number of fish caught, estimated by barrels, in 1876	1,708,166
Number of fish caught, estimated by barrels, in 1877	1,958,747
Gain	250,581
Number of gallons oil made in 1876	2,992,000
Number of gallons oil made in 1877	2,426,589
Loss	566,589
Number of tons guano made in 1876	51,245
Number of tons guano made in 1877	55,444
Gain	4,199

* The difference in capital reported in 1877 from 1876, is mainly represented by factories not in operation, and is more properly idle capital than "loss."—SECRETARY

In 1877, 5,700 tons of dried scrap were made by the oil and guano manufacturers.

Number of gallons oil held by manufacturers January 10, 1877	264,000
Number of gallons oil held by manufacturers January 9, 1878	86,000
Amount less than in 1877	178,000
Number of tons guano held by manufacturers January 10, 1877	7,275
Number of tons guano held by manufacturers January 9, 1878	1,640
Amount less than in 1877	5,635

After the report had been accepted and committee discharged, the secretary *pro tempore* read a paper from Dr. Maylert on the subject of scrap-drying. Remarks upon the same subject were also made by Professor D'Homergue.

Prof. S. L. Goodale then addressed the association upon his method of extracting or liberating the oil from fish scrap. A general discussion then took place upon the subject of scrap-drying, and the several new methods proposed to accomplish the object. Much attention is being given to this important matter, and the amount of scrap dried the past season was probably double that of any former year, and as the demand is increasing each year, and the saving in ammonia in the dried material is so large an item, it is hoped that some simple, inexpensive method will soon be found for accomplishing the desired results. The meeting of the association was quite fully attended, and the most interesting yet held.

The statistics gathered are believed to be the most accurate of any yet obtained. The stocks on hand, of both oil and guano, are very small. The outlook for the coming season is quite favorable, and better prices will doubtless be obtained than for the past few years. Ammoniacal matter is scarce, and in demand at good prices.

H. L. DUDLEY, *Secretary.*

APPENDIX M.

ANNUAL REPORTS OF THE ASSOCIATION OF MENHADEN OIL AND GUANO MANUFACTURERS IN THE STATE OF MAINE.

First annual report, for the year 1873.

Names and post-office address.	Amount of capital invested.		Number of fishermen employed.	Number of vessels.	Number of steamers.	Average number of men at works.	Number of barrels of fish taken at works.	Number of barrels of fish sold for bait.	Number of gallons of oil made.	Tons of crude guano made.
	Factory.	Fish-gear.								
L. Brightman & Sons, Round Pond, Me	$30, 000	$60, 000	80	5	3	30	49, 000	100	135, 000	1, 500
Judson, Tarr & Co., Pemaquid, Me	50, 000	60, 000	60	2	4	27	61, 000	200	175, 000	1, 800
Albert Gray & Co., Round Pond, Me	14, 000	14, 000	15	1	1	17	25, 000	100	70, 000	750
Joseph Church & Co., Round Pond, Me	60, 000	60, 000	60	2	4	50	86, 000	....	250, 000	2, 100
Gallup, Morgan & Co., East Booth Bay, Me	12, 000	7, 000	27	3	0	9	22, 000	500	55, 000	680
W. A. Wells & Co., South Bristol, Me	7, 000	20, 000	25	2	1	15	22, 913	250	62, 000	700
Gallup & Holmes, East Booth Bay, Me	12, 000	10, 000	36	3	0	10	15, 000	400	45, 000	470
Kenniston, Cobb & Co., Booth Bay, Me	12, 000	15, 000	40	4	0	11	18, 000	327	53, 800	615
Atlantic Oil Company, Booth Bay, Me	32, 000	33, 000	60	6	1	24	43, 000	500	120, 000	1, 800
Round Pond Oil Works, Round Pond, Me	12, 000	4, 000	30	3	0	15	16, 500	....	43, 255	450
Bristol Oil Works, Round Pond, Me	10, 000	18, 000	20	0	2	15	22, 000	....	55, 000	600
Suffolk Oil Works, East Boothbay, Me	25, 000	30, 000	60	5	1	16	41, 000	600	120, 000	1, 300
Loud's Island Oil Works, Round Pond, Me	2, 500	4, 000	20	2	0	10	8, 000	....	20, 000	200
Totals	278, 500	335, 000	533	38	17	249	429, 413	2, 977	1, 204, 055	12, 965

Second annual report, 1874.

Names and post-office address.	Amount of capital invested.		Number of fishermen employed.	Number of vessels.	Number of steamers.	Average number of men at works.	Number of barrels of fish taken at works.	Number of barrels of fish sold for bait.	Number of gallons of oil made.	Tons of crude guano made.
	Factory.	Fish-gear.								
L. Brightman & Son, Round Pond, Me	$30,000	$60,000	80	3	4	40	82,000	....	260,000	2,600
Judson, Tarr & Co., Pemaquid, Me	60,000	60,000	50	1	4	30	67,000	2,000	200,000	2,150
Albert Gray & Co., Round Pond, Me	20,000	35,000	24	1	2	20	46,000	....	153,665	1,350
Joseph Church & Co., Round Pond, Me	65,000	55,000	70	3	4	70	138,000	200	450,000	4,000
Gallup, Morgan & Co., East Boothbay, Me	5,000	19,000	27	2	1	13	29,472	500	88,264	960
W. A. Wells & Co., South Bristol, Me	10,000	25,000	20	2	1	16	30,000	....	93,000	900
Gallup & Holmes, East Boothbay, Me	15,000	10,000	50	4	0	12	25,000	500	71,000	730
Kenniston, Cobb & Co., Boothbay, Me	15,000	15,000	50	5	0	10	28,389	1,000	84,108	850
Atlantic Oil Company, Boothbay, Me	40,000	60,000	60	3	3	20	64,000	3,000	193,000	2,450
Round Pond Oil Works, Round Pond, Me	15,000	3,000	30	6	0	15	27,000	....	87,000	850
Bristol Oil Works, Round Pond, Me	8,000	12,000	20	0	2	16	33,000	100	102,000	800
Suffolk Oil Works, East Boothbay, Me	25,000	30,000	50	4	1	16	29,000	2,900	83,000	950
Loud's Island Oil Works, Round Pond, Me	5,000	3,000	20	2	0	12	15,000	200	14,000	500
R. A. Friend, Brooklin, Me	3,000	3,500	10	1	0	14	8,000	....	22,000	205
Totals	316,000	390,500	561	37	22	304	621,861	10,400	1,931,037	19,295
Increase over 1873	37,500	55,500	28	1 dec.	5	45	192,418	7,423	726,982	6,330

Third annual report, 1875.

Names and post-office address.	Amount of capital invested.		Number of fishermen employed.	Number of vessels.	Number of steamers.	Average number of men at works.	Number of barrels of fish taken at works.	Number of barrels of fish sold for bait.	Number of gallons of oil made.	Tons of crude guano made.
	Factory.	Fish-gear.								
Joseph Church & Co., Round Pond, Me	$85,000	$60,000	100	2	5	80	153,000	....	446,000	4,500
Tuthill & Co., South Bristol, Me	12,000	16,000	20	1	1	11	16,583	255	48,428	500
J. G. Nickerson & Co., Hodgdon's Mills, Me	40,000	50,000	80	5	3	13	43,620	1,432	114,380	1,375
John Hastings, Round Pond, Me	15,000	8,000	30	3	....	14	14,000	500	37,000	400
Gallup & Holmes, Hodgdon's Mills, Me	20,000	30,000	50	2	2	18	32,000	600	86,000	900
Kenniston & Cobb, Boothbay, Me	15,000	10,000	50	5	....	12	21,323	1,000	56,656	714
Fowler & Foot, South Bristol, Me	18,000	18,000	36	2	1	18	16,000	800	36,400	450
George W. Miles & Co., South Bristol, Me	25,000	32,000	50	2	2	15	25,000	....	71,000	850
Wells & Co., South Bristol, Me	10,000	30,000	32	1	2	17	28,000	300	76,000	510
Gallup & Morgan, Hodgdon's Mills, Me	11,000	20,000	37	2	....	17	29,545	865	75,017	1,016
Loud's Island Oil Company, Round Pond, Me	4,000	4,000	20	2	....	9	12,300	....	30,000	400
L. Brightman & Son, Round Pond, Me	30,000	60,000	96	3	4	45	83,000	1,000	20,000	2,500
Albert Gray & Co., Round Pond, Me	25,000	25,000	40	1	3	30	53,000	....	135,000	1,680
Bristol Oil Company	8,000	14,000	30	2	1	20	24,000	....	70,000	800
Round Pond Oil Company	15,000	5,000	30	3	....	16	18,000	....	45,000	550
Atlantic Oil Company, Boothbay, Me	60,000	80,000	60	....	6	25	56,000	4,000	140,000	2,000
Job T. Wilson, Blue Hill, Me	4,000	20,000	10	....	1	13	10,400	....	28,000	250
Totals	397,000	482,000	771	36	31	373	635,771	10,752	1,514,881	19,395
Gain over 1874	81,000	91,500	210	....	9	69	....	....	....	100
Loss from 1874	....	....	....	1	....	....	13,910	352	416,156	....

Fourth annual report, 1876.

Names and post-office address.	Amount of capital invested.		Number of fishermen employed.	Average number of men at works.	Number of steamers.	Number of vessels.	Number of barrels of fish taken at works.	Number of barrels of fish sold for bait.	Number of gallons of oil made.	Tons of crude guano made.
	Factory.	Fish-gear.								
Joseph Church & Co., Round Pond, Me.	$80,000	$75,000	120	50	7	2	201,000	150	600,000	6,000
Atlantic Oil Company, Booth Bay, Me.	60,000	75,000	60	25	6	....	51,878	1,800	139,000	1,595
C. H. Tuthill & Co., South Bristol, Me.	10,000	28,000	30	14	2	1	27,960	....	89,000	825
Albert Gray & Co., Round Pond, Me.	15,000	30,000	50	30	3	1	45,000	150	129,000	1,300
George W. Miles & Co., South Bristol, Me.	25,000	32,000	25	20	2	....	37,000	....	121,700	1,121
Wells & Co., South Bristol, Me.	10,000	30,000	30	18	2	....	30,000	....	87,000	1,060
Gallup, Morgan & Co., East Booth Bay, Me.	10,000	25,000	35	15	2	1	34,763	....	111,018	1,100
Gallup & Holmes, East Booth Bay, Me.	18,000	36,000	40	18	3	....	40,900	....	135,555	1,230
Fowler, Foote & Co., South Bristol, Me.	18,000	30,000	38	14	2	3	26,250	2,832	85,000	825
L. Brightman & Son, Round Pond, Me.	50,000	60,000	60	40	4	2	48,000	....	146,000	1,450
Round Pond Oil Company, Round Pond, Me.	8,000	4,000	40	15	....	4	22,000	2,000	72,000	660
Bristol Oil Company, Round Pond, Me.	8,000	8,000	30	13	1	2	25,653	200	80,000	800
Suffolk Oil Company, East Booth Bay, Me.	40,000	40,000	50	15	2	3	26,916	....	82,500	850
Kenniston, Cobb & Co., Booth Bay, Me.	15,000	10,000	50	17	1	4	14,474	300	39,500	483
Pemaquid Oil Company, Pemaquid, Me.	50,000	60,000	50	40	4	1	60,000	....	180,000	2,000
Brown's Cove Company, Round Pond, Me.	10,000	5,000	30	15	....	3	5,000	1,000	15,000	175
Loud's Island Company, Round Pond, Me.	4,000	4,000	20	12	....	3	13,000	....	28,000	....
Total	431,000	552,000	758	371	43	29	709,000	8,432	2,143,273	21,414
Gain over 1875	34,000	70,000	....	....	12	....	73,229	....	628,392	2,019
Loss from 1875	....	....	13	2	....	7	....	2,320	....	....

Fifth annual report, 1877.

Names and post-office address.	Amount of capital invested.		Number of fishermen employed.	Number of vessels.	Number of steamers.	Average number of men at works.	Number of barrels of fish taken at works.	Number of barrels of fish sold for bait.	Number of gallons of oil made.	Tons of crude guano made.
	Factory.	Fish-gear.								
Joseph Church & Co., Round Pond, Me	$80,000	$120,000	140	2	8	60	182,000	700	365,781	5,400
Albert Gray & Co., Round Pond, Me	15,000	40,000	50	1	4	30	27,000	300	44,000	800
Gallup & Holmes, East Booth Bay, Me	20,000	50,000	60	......	4	20	51,847	100	121,000	1,500
Gallup, Morgan & Co., East Booth Bay, Me	18,812	25,800	28	......	2	15	23,760	150	47,880	700
Bristol Oil Works, Round Pond, Me	15,000	20,000	40	......	3	15	22,500	200	53,500	600
Round Pond Oil Works, Round Pond, Me	15,000	6,000	50	4	......	15	5,500	......	8,500	150
Tuthill, French & Co., South Bristol, Me	10,000	32,000	30	......	3	13	27,176	3,237	65,000	800
Loud's Island Oil Works, Round Pond, Me	12,000	13,000	42	2	1	12	9,600	......	15,680	275
Maddocks Oil Works, Booth Bay, Me	60,000	70,000	66	......	6	20	51,610	1,500	118,000	1,600
Pemaquid Oil Works, Bristol, Me	50,000	50,000	65	......	5	30	64,031	1,508	130,000	1,900
Fowler, Foote & Co., South Bristol, Me	18,000	24,000	42	3	2	13	17,721	340	39,872	562
Suffolk Oil Company, East Booth Bay, Me	30,000	15,000	28	1	2	18	22,200	1,200	51,000	740
George W. Miles & Co., South Bristol, Me	25,000	34,000	30	......	2	15	20,000	1,000	45,000	725
Brown's Cove Company, Round Pond, Me*	15,000	8,000	......	......	......	......	......	......	......	......
Kenniston, Cobb & Co., Booth Bay, Me*	15,000	10,000	......	......	......	......	......	......	......	......
Wells & Co., South Bristol, Me	15,000	45,000	40	......	3	12	19,200	500	40,000	562
L. Brightman & Son, Bristol, Me†	30,000	60,000	......	......	......	......	......	......	......	......
South Saint George Oil Works, South Saint George, Me	26,000	11,000	26	......	2	12	13,000	60	21,000	352
Total	459,812	623,800	727	13	48	300	557,145	10,795	1,166,213	16,666
Gain over 1876	28,812	71,800	......	......	5	......	......	2,363	......	......
Loss from 1876	......	......	31	16	......	71	151,855	......	977,060	4,748

* Not operated this season.

† Not operated; business changed to drying scrap.

APPENDIX N.

STATEMENTS OF CORRESPONDENTS.

These statements are given in the words of the correspondents, being answers to the circular reproduced in Appendix A. The numbers of the answers correspond to those of the questions in the circular. All the statements included in this appendix have been reviewed in the main report. The commission does not necessarily indorse them.

1. *Statement of W. H. Sargent, Castine, Me., January* 26 *and December* 28, 1874.

1. Menhaden and pogy, interchangeably.
2. Most abundant.
3. Not so numerous in creeks, coves, inlets, &c., but on the coast, outside of small bodies, it is not decreased.
4. Friend & Co., 25,000 barrels; Allen & Co., 15,000; others, 85,000. In the years from 1863 to 1868, some years 500,000 barrels were taken.
5. It does; especially around and near shores.
6. About the 25th of May. Main body arrives about the middle of June. The last are largest and fattest, usually. Usually two principal schools; the first large school, June 15; the last, September 1 to 10.
7. Swim high. Always make their arrival known by their ripple.
8. Come from the south, between Cape Cod and Cape Sable. Usually first seen just outside of headlands; and as they come into bays, rivers, &c., the main body breaks up.
9. Their appearance is certain. More abundant some seasons. Some seasons they are abundant on the coast of Massachusetts and scarce on the coast of Maine. No two give reasons alike.
10. Undoubtedly catching by any method tends to frighten them; but running refuse water and other refuse from the fish does more harm.
11. They follow the tide in and out creeks, coves, &c.
12. They seem to prefer the still waters of our bays, coves, &c.
13. They are a surface fish, but are sometimes caught thirty feet below.
14. I judge that it does, as they go south on the approach of cold weather.
15. The fish of the same school are uniform in size; some schools larger than others.
16. I have never seen them or heard of them.
17. They usually leave in October. I have known them plenty in November, but not often. I think they leave mostly together; some schools linger.
18. Outside route. General course south.
19. Have no established opinion.

20. They seldom take bait; very small fish are found in them.

22. Cannot; I think they are mixed indiscriminately.

32. Large quantities are devoured by sharks, horse-mackerel, whales, porpoises, and other fish of prey.

34 and 35. Gill-nets and seines. Gill-nets are from 30 to 80 feet long, and from 7 to 10 feet deep; seines are from 50 to 100 fathoms in length, and 5 to 15 fathoms deep.

36. All kinds and sizes. Seine-boats are uniform in size and build; they have no deck. About 35 feet long and 15 feet beam.

37. Two men can manage nets; a seine requires from 10 to 15.

38. When fish are plenty, nothing but darkness interrupts.

39. They are not, except in shoal-water places, where they are taken at high tide.

40. They "school" best in calm weather; consequently more easily taken.

41. I should judge there were 75 vessels of all sizes employed, and from four to five hundred men and boys. Very many who live on the shores fish with nets, tending their nets with small boats, hardly going out of sight of their homes for the season.

42. Nearly all are pressed for the oil; many are used for fish-bait; mostly shipped to Boston.

43. There are two or three factories owned by Rhode Island and New York parties, not worked so much now as formerly. R. A. Friend & Co., of Brooklin, are the largest resident manufacturers, but there are about one hundred smaller or private concerns who carry on the business in connection with other business.

44. The aggregate, 1,625 barrels. Friend, about 700 barrels; Chatto, 350 barrels.

46. Large factories, steam; smaller ones, the common bed-screw.

47. Slivered, they are worth, put up, about $6 per barrel; in 1863 they were worth $4; prices vary with the quantity.

48. When poor, July, 200; very poor, 1st June, 250; fat, August, 150; very fat, October, 100.

49. About one ton of scrap is obtained in making three barrels of oil.

50. Three quarts is the least I ever knew; from the first school.

51. Six gallons is the most I ever knew; from the last school.

52. Yes.

53. The first oil made in this region was made by a man named Bartlett, residing on an island in the town of Bluehill, Hancock County, Maine. About the year 1837 he sent a small phial-full to Boston to have it tested. Meeting with encouragement, he commenced in a small way to manufacture by setting a common iron kettle over a fire, filling the kettle with fish, and with a strong cover under a heavy beam, "cider-press" fashion, pressing the oil into a vat. From that time the manufacture increased fast in this section. For about twenty years gill-nets were used exclusively for taking the fish.

54. Boston.

55. Much is used by farmers in the vicinity of its manufacture, but a larger quantity is shipped to Boston, New York, and Baltimore.

56. Generally, I think, for lubricating purposes.

57. In 1873 and four previous years, from 35 to 46 cents a gallon. In 1862, $1.40 a gallon.

58. It is certain that they have diminished on this coast.

---

2. Statement of J. C. Condon, Belfast, Me. Communicated by Marshall Davis, deputy collector, Belfast, Me.

Your circular, addressed to this office, making inquiries relative to a species of fish found here and called by us pogy, was duly received, and I have the honor to return to you the following answers to your questions, the most of which I will here state were obtained from Mr. J. C. Condon, of this place, who for some years has been engaged to some extent in catching the fish and manufacturing the pogy oil.

1. Your first question I have already answered. We call them pogy.

2. The fish are quite abundant here.

3. Their numbers have diminished.

4. Two thousand barrels of fish in this (Castine) district.

5. It does not appear to, here.

6. The first of June are first seen; most abundant the last of June and into July; come in schools. The second school usually comes ten days later than the first, and the fish are larger, the first being the younger fish.

7. They swim near the surface and make a ripple on the water.

8. They follow the coast from the south.

9. They come every year, but some years later than others.

10. Much fishing with nets would frighten them farther from the shore.

11. Will school out with the ebb, and in with flood.

12. Inside schools come up into the bays near the shore and outside schools play from Portland to Mount Desert. Inside schools are younger and smaller fish.

13. The depth of water makes no difference, as they swim near the surface.

14. They seek warmer water in fall and winter.

15. They breed south and do not reach here until two or three years old.

16. No fish are found here younger than two or three years.

17. They leave in October and November in a body.

18. Follow the coast southerly.

19. On the southern coast.

20. The most that is found in them that seems to be their food, is a small seedlike-looking substance called by fisherman brit.

21. They spawn in southern waters, it is supposed.

22. They go in schools, and not in pairs.

23. We cannot answer that here.

24. We presume warmer than the water here.

25. In shallow water it is supposed.

31. A sort of spider is found on the back of the fish, near the fin, the spider having a tail that looks like moss.

32. Whales live on them and sharks and bluefish devour them.

33. Never have known anything like disease appear among them.

34. They are caught with seines and nets.

35. The seines are 150 fathoms long and 20 fathoms deep. Nets 20 fathoms long and 4 deep.

36. The vessels used in taking them are sail-vessels of 50 tons burden, and small steamboats of 100 tons.

37. Ten men are wanted for one vessel, and one seine.

38. They fish all day.

39. They are taken equally well on flood or ebb tide.

40. The wind has no perceivable effect upon them.

41. There are, in this district, about 25 vessels, with 5 men to each.

42. The fish are caught here for oil and mackerel bait.

43. There are two small oil-factories here, one owned by J. C. Condon (of whom I get this information) and one by J. C. Mayo.

44. Condon makes 50 barrels and Mayo 25 per year.

45 and 46. Their factories could produce much more.

47. Sixty cents per barrel of 200 pounds of fish.

48. One barrel fish will make (ordinarily) three gallons of oil.

49. One ton of scrap will make 30 gallons oil.

50. The first fish that come in the spring will produce but one gallon oil to a barrel of fish.

51. In October a barrel of fish will produce from 4 to 5 gallons oil.

52. The northern fish yield four times as much oil as southern.

53. About twenty years ago, a woman living at Buck's Harbor, in Brooksville, was frying some of the fish to eat, and observing how very full of oil they were, suggested to her husband that it would pay to try them out for the oil, and he having an eye to interest, tried the experiment, by using their washboiler to try them and their tub for a press. In this way they made one barrel of oil, carried it to Boston and sold it to a Mr. Eben Philips, an old oil-dealer, who at once saw money in the enterprise, and so furnished these people with nets, kettles, and a press for their next year's business, the product of which was eight barrels of oil. After that, others seeing their prosperity, went into the business, which from that has grown to its present amount.

54. The oil is marketed mostly in Boston.

55. The scrap is mostly sold here to farmers for dressing their land.
56. The oil is mostly used for currier purposes in dressing leather.
57. The oil has sold at prices varying from 40 to 50 cents per gallon.
58. We presume it does somewhat.

---

3. Statement of R. A. Friend, Brooklin, Me.

1. Pogy.
2. Greatly in excess.
3. Apparently as plenty as in past years.
4. About 14,000 in 1873; 23,000 in 1874.
5. It does not.
6. Main body arrives from first to middle of June; usually three runs.
7. High; ripple on water; attract birds.
8. By south channel.
9. Regular and certain.
10. It does not.
11. They go with the tide.
12. In large bays.
13. No special depth; unknown.
14. It does.
16. Never.
17. From the middle of September to the middle of October; by degrees.
18. Following the coast.
19. South.
20. I should think vegetable nature.
21. Mostly south of Cape Cod.
31. Frequently have jiggers attached.
32. To a great extent.
33. Not here.
34. Seines and mash-nets.
35. Seines 8,000 meshes long, 650 deep; gill-nets 3 to 5 fathoms deep, 20 fathoms long.
36. Small schooners and steamers, with luggers; from 5 to 100 tons.
37. Seine, 12 men; gill-nets, 3 to 5.
38. Seines, all times of day; nets, morning and evening.
39. Most on ebb-tide.
40. It seems to.
41. Five; fifty-five.
42. Manufactured for oil and scrap; sent away to factories.
43. Robert A. Friend, P. Kane, Harriman Point Company, Job T. Wilson & Co.
44. Averaged 14,000 gallons the past two years.

45. R. A. Friend 50,000 gallons; Job T. Wilson 50,000 gallons; P. Kane 15,000 gallons; Harriman Point Company 20,000 gallons.

46. Job T. Wilson, steam; R. A. French, steam and pot works; others, pot-works.

47. Sixty-five cents (1873).

50. Two quarts; in June.

51. Four gallons; last of August.

53. First made by William Romer; oil taken from pots where fish were cooked for fowls.

54. Boston.

55. Boston, Philadelphia, and Baltimore.

56. Painting and currying.

57. Forty-five cents; from 30 cents to $1.27.

58. It is not.

---

4. *Statement of John Grant, Matinicus Light Station, Matinicus Rock, Maine, March* 31, 1874.

1. Menhaden or pogy.

2. More abundant than any fish except herring.

3. Diminished.

4. No regular establishment or factory is run in this vicinity.

5. I think it does.

6. About the 1st of June. The larger body come about the middle or last of June. The last schools are the largest and fattest. There are commonly several schools at irregular intervals.

7. They swim high, making a ripple, and frequently showing their fins and attracting sea-gulls and other birds in great numbers.

8. They come from the south, and when driven into bays and rivers by large fish they inhabit one locality for several weeks at a time.

9. Regular.

10. Yes.

12. Between Seguin and Matinicus Rock and the bays and mouths of rivers between these points.

13. Usually on or near the surface of the water, but sometimes at the depth of 20 or 30 fathoms.

15. Yes.

16. No very young ones.

17. About the middle of October, in a body.

18. By the same, as they came rather working westward.

19. South of Cape Hatteras, near the Gulf Stream.

20. Some floating substance on or near the surface of the water.

21. Probably near the edge of the stream, south of Hatteras, during the winter season.

28. I have found them in Hampton Roads in early spring, when they were not more than two inches.

29. No.

31. No.

32. Considerably. The whale, I think, is their greatest enemy. Rising beneath the schools, as they play upon the water, with extended jaws, he forces himself up through them with such speed as to project his body half out of water, closing his jaws over large quantities of fish as he falls heavily back.

33. No.

34. Seines from 150 to 300 fathoms in length and 20 fathoms in depth, and nets about 30 fathoms in length and from 2 to 3 fathoms in depth.

35. Answered above.

36. Small schooners. Recently fifteen to twenty small steamers have been employed, the tonnage of which amounts to 1,500 tons.

37. About 500 men.

38. The fish are taken by some fishermen with set nets whenever they come to the surface.

39. No.

40. They "school" or come to the surface best in moderate winds and calms.

41. No vessels are fitted out for this business in this immediate vicinity, but large quantities of fish are taken between this station and Monhegan by vessels from other parts of the coast.

48. About 250.

50. One and a half gallons, when the first fish appear on the coast.

51. Three gallons. About the 1st of October.

52. Yes.

53. Can give no definite history.

54. Boston and Portland.

56. Painting and tanning.

58. Undoubtedly.

---

5. *Statement of Benjamin F. Brightman, Waldoborough, Me., March* 18, 1874.

1. Pogy.

2. The most abundant, to all appearances, as we see these and do not see the other kinds.

3. About the same, I think.

4. There were taken in the mine about 350,000 barrels by all the factories, viz: Bristol, Bremen, Joseph Church & Co., Round Pond, Loud's Island, L. Brightman & Sons, Judson Tarr & Co., Union, Wells Deblois & Brown, Kenniston, Cobb & Co., Gallup & Manchester, Gallup & Holmes, J. G. Nickerson, L. Maddocks, factories the present year, and about the same in previous years.

5. See no difference.

6. About the 1st of June the first fish make their appearance, usually scattering; commence taking in seines about the 15th. They are poor

then, and rather smaller than the fish caught in August and September, when we go off shore from 5 to 30 miles and get larger and fatter fish. We commence about the 15th of June, and fish until the 15th of October.

7. High and low both. When they are up and we can see them we get them, and when down we cannot fish, so that some days there will be good fishing and others none at all. On the seine-ground, cannot tell how deep they swim when they are down. We usually catch them here by seeing them play. Sometimes they ripple the water.

8. From southeast to the southwest, and generally lay along the coast; they are seen from Cape Sable to Cape Ann, off and on shore around Cape Cod, in the season of them—that is, an outside fish and an inside fish. Fish in the bays and rivers are called inside, and on the ocean called outside. In Maine, the fishing is done outside nearly altogether.

9. About the same for the last ten years. The fish go where the feed is.

10. See no difference.

11. Has no effect here.

12. Usually deep water.

13. We fish in deep and shoal water. Do not know how deep they swim.

14. In a sunshiny day we see them most.

15. Never saw any fish here that looked as though they came here to breed; there is some difference in the size, but could not define their age. The smaller fish go into the rivers.

16. Never saw a young fish north of Cape Cod, or old fish that looked like spawning.

17. The fish start to go west from here about the middle of September, and go by degrees up to the last of October.

18. They seem to run along the coast southwesterly.

20. It is a substance in the water which is sometimes seen; I never examined it particularly. Something like a seed or a very small lobster, or rather has this appearance; it is about one-fourth of an inch long; do not see as much of that here as in Narragansett Bay.

21. From the south side of Cape Cod to the Albemarle Sound, in all the inland waters and rivers, mostly in the southern waters, commencing south about the 1st of March and in Narragansett Bay in May.

22. Think the spawning fish leave the main body and scatter about in pairs or small schools and in shoal water.

23. Never saw the operation, but have noticed in the smoother waters in the night that the fish came close in to the shore in shoal water, and the supposition was that they were spawning. I have seen a hauling-seine haul on shore the spawns all ready to hatch.

24. The water is rather cold in the spawning season.

25. Any depth, but usually in shoal water, on the bottom.

26. Lay on the bottom.

27. In about six weeks after being laid.

28. They are in great abundance; saw more young fish in Narragansett Bay last season than ever before, but their usual spawning-grounds are south as far as Cape Lookout, mostly about the Potomac and Delaware Bay and joining shores.

29. Never saw the spawn running from the fish. We never catch them with the purse-seine for the reason that they leave the body of fish and scatter about. The spawning fish are among the first to arrive.

30. Do not know as I ever saw menhaden spawn in any other fish. The parent fish do not devour them.

31. Have seen a small crab in the fish, just under the scales, with an appendage about an inch long; never saw anything in or around the mouth.

32. They suffer to a great extent from bluefish, horse-mackerel, porpoise, sharks, whales, dog-fish, &c.

33. Never saw any diseases about them.

34. There are a great many caught in gill-nets in the first part of the season, but not so many here as formerly. The nets are made of fine cotton twine, about 4 inches mesh, and all set or anchored; the fish run into them and put their heads through the mesh. They are about 20 fathoms long and 12 feet deep.

35. The purse-seines here are made from 200 to 225 fathoms long and 100 feet deep in the middle and 70 at the ends made of fine cotton twine.

36. A small schooner of about 30 tons, with two or three open boats carrying about 200 barrels each, two men in each boat. The crew live on board the tender and lay on the fishing-grounds and the boats carry the fish to the works. The most of the fish here are caught in steamers of about 60 tons, from 30 to 50 horse-power. The steamers work better than sail gangs, on account of running in calm weather; there are 17 in the eastern fleet; they carry from 500 to 1,200 barrels each.

37. From 10 to 12 men to each gang.

38. Usually in the morning, from daylight to ten o'clock, or just at night. In calm weather all day.

39. Rather better on the rising tide.

40. We cannot keep run of the fish as well when the wind blows.

41. Fifty-four gangs, of from 10 to 12 men each. This comprises the section between the Kennebec and Penobscot Rivers. There is nothing done in Maine outside of this section except one or two gangs in Blue Hill Bay, and the next fishing-grounds are at Narragansett Bay, west, and around Long Island.

42. Carried to the factories in this vicinity.

43. The most are stock companies, but some are owned by individuals. This question is answered in question 4.

44. From 25,000 to 225,000 gallons, according to capacity. There is a great difference in the capacity; three factories here made one-quarter of the oil and one-sixth of the scrap made in the whole country.

45. From 40,000 to 500,000 gallons, if they could get fish and they were fat enough.

46. The cost of factories, including machinery, varies from $10.000 to $70,000, not including fish-gear and gangs.

47. Sixty-five cents were paid the last two years, but they have been as high as $1 when oil was higher.

48. Our eastern fish average about 2½ gallons to the barrel.

49. From 30 to 40 barrels.

50. Our first fish make about three quarts to the barrel; only a few of these caught.

51. Four gallons in August and September, when we go to sea after the fish.

52. The average is greater north, although the fattest fish caught last year, Southold Bay, Long Island, 7 gallons to the barrel.

53. The factories in Maine were built ten years ago. Since then there have been some twenty built; there are fourteen in operation now, or will be in the season of fishing.

54. Boston and New York.

55. The manufacturers of superphosphate use principal part of it, although the farmers use it as it comes from the factory; it is too strong of ammonia to use raw, varying from 7 to 12 per cent.

56. Mostly used for tanners' oil.

57. Forty to sixty cents per gallon. Have known it to be sold for $1.35 per gallon.

58. Do not see any variation for the last ten years.

---

6. *Statement of L. Maddocks, Booth Bay, Me., December* 25, 1877.

The names and tonnage of my steamers are as follows: Steamer Mabel Bird, 80 tons; steamer M. M. Fish, 80 tons; steamer Grace Darling, 75 tons; steamer Phebe, 70 tons; steamer S. L. Goodale, 70 tons; steamer H. M. Price, 20 tons.

---

7. *Statement of G. B. Kenniston, Booth Bay, Me., February* 14, 1874.

1. Known about equally as pogy and menhaden.

2. It is found in numbers almost incomparably greater than any other.

3. Increased.

4. In this town (Booth Bay), in 1873, were taken 152,000 barrels, as follows: Kenniston, Cobb & Co., 17,000; Gallup and Holmes, 17,000;

Gallup and Manchester, 25,000; Suffolk Oil Works, 48,000; Atlantic Oil Works, 45,000. In 1872 the aggregate reached about 110,000 barrels. In 1871, with six factories instead of five, were taken about 95,000 barrels. In 1870 less than 75,000 barrels were taken, while in 1866, the first year of work here, not more than 35,000 barrels were taken. The great difference in these results may be ascribed to three causes: (1.) The fishermen have acquired skill in the business. (2.) Much better apparatus for the capture of these fish is now in use. (3.) The fish are more abundant than formerly.

5. Not perceptibly.

6. First seen about May 20 in occasional schools. Main body arrives about June 20, which, passing eastward, is followed by others continually for about thirty days longer. There is considerable difference in the size of fish caught. At times, mixed sizes are taken at the same set; usually, these arriving at different periods of time, differ in size. Larger may come sooner or later. Nothing certain is known as regards this.

7. Probably near the surface. Their arrival is known only by their "play," *i. e.*, flipping, or striking the water with their tails.

8. After rounding Cape Cod, some touch the coast in the vicinity of Gloucester, Mass., but the larger portion, by far, it appears, keep off shore, and near it anywhere from Cape Elizabeth to Monhegan. The main body of these fish continue to pass toward the east till about the 20th of July, when that impetus seems to be checked, and for thirty or forty days their movements are seemingly local. Then they begin their return to the west, and continue to repass, until in October the last bodies are urgent in the westward course.

9. Very regular. Never fail to come.

10. Yes. They are farther off shore, but not, it is believed, from their feeding-ground.

11. No relation discoverable.

12. In this vicinity, from five to thirty miles from land.

13. Depth not material.

14. No. Temperature of air does. They will not "show" or come to the surface when cold north or east winds prevail.

15. No.

16. No.

17. In September and October, as described in No. 8.

18. By the same as that by which they arrive; described in No. 8.

19. About the Bahama Banks and Florida Keys.

20. Animalculæ.

21. Where they pass the winter (No. 19) in January and February.

22. The writer has reason to believe them to be indiscriminately mixed.

23. Yes.

24. Am unable to give the temperature of Bahama waters.

28. Yes. About the sounds of Carolina and Chesapeake Bay.

29. Never in Maine. It will appear in late southern fishing, November and December.

30. Am unable to say. Parent fish does not devour them.

31. Worms occasionally found in the head.

32. Immensely.

33. Never.

34. Seines.

35. Length, 500 yards; depth, 60 yards.

36. Steamers, schooners, and sloops varying from 20 to 70 tons, new measurement.

37. Ten usually make a crew.

38. While they can see. From daylight till dark.

39. No.

40. Prevents their capture by "raising a sea." Cold winds cause them not to "show."

41. In Booth Bay, 21 crews, 210 men.

42. Sent at once to the works to which the catching crew belong Each gang fishes for the factory which provides the apparatus for fishing.

43. They number six: A. Suffolk Oil & Guano Works, J. G. Nickerson. B. Atlantic Oil & Guano Works, Luther Maddocks. C. Works of Gallup & Holmes. D. Works of Gallup & Manchester. E. Works of Kenniston, Cobb & Co. F. White Wine Brook Company's Works, G. B. Kenniston and others.

44. Depends wholly on the number of barrels of fish secured and their fatness, both of which vary each year. For 1873 the following is about the result, using letters as above to designate the figures: A. 120,000 gallons. B. 112,000 gallons. C. 42,500 gallons. D. 62,500 gallons. E. 42,500 gallons. F. Not run.

45. Fifty per cent. in addition to the amount usually made.

46. Factories vary in cost from $10,000 to $60,000.

47. In 1873, 75 cents per barrel. In previous years, from 50 cents to $1.25 per barrel.

48. Barrel averages 2½ gallons usually.

49. Varies with the time of the season, whether it be in June or October.

50. Three pints. May.

51. Six and one-half gallons in October.

52. Yes, average; though Southern fish late (December) are very fat.

53. Began in Maine in 1865. Grew rapidly for four years. Not augmented any since 1870, except in method and means of taking the fish.

54. Boston, New York, and export.

55. Massachusetts and the Southern States.

56. Sold largely for curriers' use, and to adulterate higher-priced oils.

57. From 35 to 48 cents. Previous years, from 33 cents to $1.05.

58. Not sensibly.

The inception and growth of this business in the adjoining town of Bristol is contemporaneous with Booth Bay. In 1873, the works of that town probably pressed 250,000 barrels of fish, yielding 625,000 gallons of oil. There are about eight works.

---

8. *Statement of Judson Tarr & Co., Rockport, Mass., and Booth Bay, Me., January* 23, 1874.

1. Menhaden.

2. Are most numerous of any fish on our coast.

3. Have increased in the last ten years.

4. Number of barrels caught in Maine during 1873 was about 400,000, of which we caught 60,000.

5. The extensive capture does not lessen their abundance. Should say they have increased within five years, but not so abundant inshore.

6. Menhaden are first heard from in March as far south as Cape Henry. They come on the coast of Maine about June 1, but the main body does not get along until June 20; they are then constantly coming along until July.

7. They come in schools and make a ripple on the surface of the water.

8. They usually follow the shore in coming and going.

9. They never fail.

16. Never see any small fish on the coast of Maine.

17. They leave our coast about October 1. Cold weather drives them south.

19. Think they go as far south as Florida.

20. A sort of red seed, floating on the surface.

21. They spawn South.

30. The larger fish, such as the whale and shark, are their greatest enemy. The blue-fish destroy great quantities.

34. They are caught with seines.

35. One thousand to 1,500 feet long and 100 feet deep. They are called purse-seines, and cost $1,000 each.

36. Vessels and steamers of from 40 to 100 tons are used in catching them.

41. Whole number of vessels, 33; 17 of which are steamers. There are about 500 fishermen.

44. Number of gallons of oil produced by all, 1,000,000; tons of scrap, 12,000.

50. Yield less than one gallon to the barrel.

51. They yield most oil in September.

56. It is used principally for currying purposes.

57. Average price of oil, 45 cents per gallon; scrap, $15 per ton.

The phosphate that is made from the scrap is used mostly in the South.

ern States for raising cotton. Considerable is also used for raising tobacco. Used to a certain extent in every State in the Union. This business is prosecuted quite extensively in Narragansett Bay and Long Island Sound, Rhode Island, Connecticut, and New Jersey. Commences one month earlier, and lasts one to two months later in season. The whole number of factories in that vicinity is about 50, but many of them are small. The amount of capital invested is $1,500,000. The number of barrels of fish caught is 793,100; amount of oil, 1,200,000 gallons; amount of scrap, 24,000 tons.

Size of our factory: Main building, 130 by 40 feet, 16 feet post, having two stories. The upper one is used for cooking and pressing fish; the lower story for oil-room and fish-scrap. The engine-house adjoining the factory is 20 by 30, 10 feet post, containing three horizontal boilers, 65 horse-power each. In the upper part of factory there are eleven cooking-tanks made of wood, round, 12 feet in diameter and 4 feet deep, with steam-pipes in the bottom, having several small holes in them to let steam into these tanks. There are also three hydraulic presses, 150 tons pressure each, and one engine of 10 horse-power. In connection with factory are two wharves, one 150 by 50, and one 40 by 80. On the largest wharf is a tank set up on posts 10 feet high. This tank has a capacity of 4,000 barrels, which we sometimes have full at night after discharging all of our steamers with their day's catch. We have a 12-horse engine on the wharf used for hoisting fish out of steamers; have three drums connected with engine so as to run all at one time or either one we wish. We can unload one thousand barrels an hour when in full blast. The fish are discharged same as coal is unloaded, and are dumped into tanks on the wharf. In connection with the factory is another building for the main scrap-house, 60 by 100, 15 feet post; also blacksmith-shop, cooper-shop, carpenter-shop, boarding-house, stable, &c., all on the premises and used in connection with the business. These cost from $75,000 to $80,000, and the steamers and fishing-gear, such as seines, small-boats, &c., not less than $60,000 more. There are but two pogy factories in the United States of this capacity, and are both in the town of Bristol, respectively owned by Joseph Church & Co., Tiverton, R. I., and L. Brightman Sons, Round Pond, Me., or Fall River, Mass. Next largest are those of L. Maddocks and J. G. Nickerson, in Booth Bay, adjoining town, about half as extensive as the above. The others are smaller. Perhaps they may average one-fourth capacity of first three.

General process of manufacturing.—First, the fish are landed on the wharf or in tanks; then they are conveyed to the upper story of the factory in cars holding about 20 barrels, on wooden rails set upon wooden horses; then they are emptied into the cooking-tanks. Put in first 6 inches of salt water, then 50 to 75 barrels of fish, in each tank, and open steam from main pipe and boil them one hour. In that way two-thirds of the oil comes out of the fish. We then draw this oil and water off below into drawing-off tanks for this purpose, and run it

through from one to another until it is run through several, keeping it hot all the while. After doing this the oil comes to the surface and the water separates and goes to the bottom. Then the oil is run off into a tank holding 4,000 or 5,000 gallons, called a settling-tank. After remaining there a few hours it is pumped up and run off into bleaching or drawing-off tanks, of which we have five, holding 4,000 gallons each. There it remains one to two weeks. Then it is put into kerosene-oil barrels and shipped to New Bedford, New York, and Boston, and sold to dealers in fish oil. In regard to pressing: After the fish are cooked or steamed and drained, then they are put into round curbs holding 10 barrels each, made of iron one-half an inch thick, perforated with holes one-eighth of an inch in diameter. These curbs are then put under a steam hydraulic press of 150 tons pressure, when the water and oil all come out together and are separated as before. Our capacity is 2,000 barrels per day, but we do not always get that amount; sometimes more and sometimes less. Oftentimes we do not have any fish for a week. We average about four fish days in a week. They are employed in Maine about sixteen weeks. First oil extracted from menhaden is said to have been done by a woman in Frenchman's Bay, near Mount Desert, Me. It was manufactured in the house on the cook-stove or fire-place, tried out in a common wash-boiler. This oil was put up in bottles and forwarded to E. B. Phillips, of Boston, and he gave the manufacturer encouragement and furnished nets and try-kettles, set up outdoors in brick, holding, say, 50 gallons. The fish were boiled and the oil skimmed off the top, and the balance was thrown away. In this way they could not get over two-thirds of the oil, and it was thought best to press the refuse, but no one knew how to do it. The first process of pressing was in tubs and barrels by making holes in them and putting rocks on top. The scrap was thrown away. This was twenty-five to thirty years ago. I do not think the porgie business will be increased any at present, as there could be an overproduction of oil. The fish are not likely to diminish. We employ at the factory about thirty-five men.

---

9. *Statement of Mrs. B. Humphrey, keeper of Monhegan Island Light, Monhegan Island, Me., February* 4, 1874.

1. Pogy.
2. They are more numerous than other kinds of fish.
3. Diminished.
5. It does.
6. The first of June. The first are the smallest.
7. The fish swim high and make a ripple on the water.
8. They follow the shore along from the southwest to the northeast.
9. The appearance of the fish on the coast is regular.
10. It does.
11. The fish play with the tide.

12. Harbors and bays.
13. They swim near the surface.
14. It does.
16. They are seen at half size.
17. They leave the coast in October and November.
18. They leave the coast by the same route that they came.
19. They winter at the South.
20. They eat the grasses and seeds on the water.
21. The fish spawn at the South.
27. They spawn south of Cape Hatteras.
28. During the winter months.
31. There is nothing attached to the mouth of the pogy.
34 and 35. Seines measuring 200 fathoms in length.
36. Steamers and sail-vessels.
37. Requires ten men to manage one vessel and seine.
38. From sunrise to sunset.
40. The wind does affect them.
41. There were no less than 111 vessels, of which 17 were steamers.
42. They are made into oil and guano at different places.
43. The nearest oil-factories are situated in Bristol, 15 miles from this place.
47. Price paid per barrel for fish is 75 cents.
48. Sixty-five fish will produce one gallon of oil.
52. The northern (Maine) fish produce more oil than southern fish (Long Island).
54. New York and Boston.
56. It is used principally for paint.
58. It does tend to diminish the fish.

---

10. *Statement of J. Washburne, jr., Portland, Me., February*, 1874.

1. Pogy.
2. Is of greater abundance than any other, except the "mackerel," and possibly the "herring" fish.
3. Has increased.
4. 440,000 barrels taken by all establishments in this State in 1873; in 1874, 632,261 barrels.
5. The extensive capture here does not appear to affect the abundance.
6. The first come about June 15; there are two schools; the first, which are small, usually come about ten days before the second school.
7. The first swim high; their arrival is first known by capture; they make a ripple and attract birds.
8. Come from the south, move north, and again to the south.

9. The appearance is quite regular, and they do not come in greater abundance one year more than another.

10. The use of nets, seines, &c., does not appear to scare them from their usual feeding grounds.

11. Does not appear to affect their movements.

12. On the coast of Maine, between Cape Elizabeth and Matinicus Islands.

13. Twenty fathoms.

15. Do not come on to breeding-grounds before maturity. Two-year-old fish are the oldest.

16. Never seen.

17. About October 1, in a body.

18. Southerly.

19. South of Cape Hatteras.

20. A seed.

21. During the winter in southern waters.

26. Spawn are never seen in these waters.

27. Eggs are never seen in this vicinity.

28. None are ever seen in these waters.

29. No.

30. Whales, sharks, blue-fish, seals, &c.; don't know that the parent fish destroy their young.

31. No.

32. Greatly.

33. Never hereabouts.

34. Pass seines.

35. Two hundred to 275 fathoms long.

36. Both steam and sailing vessels, from 40 to 150 tons chiefly; some small boats.

37. About ten men for the usual class employed.

38. Ten hours.

39. No.

40. The catch is better with a southerly wind.

41. One hundred and ten vessels, carrying an aggregate of five hundred men.

42. The fish, as soon as caught, are sent to the oil factories on shore.

43. There are thirteen oil factories on this coast owned by various individuals.

44. The quantity produced in 1873 was 1,000,000 gallons.

45. Thirteen factories, employing 446 men, caught 440,000 barrels of fish, yielding 1,000,000 gallons of oil, 13,000 tons of guano, and 2,337 barrels of bait, valued at $352,550.

46 and 47. About one dollar per barrel. During the war, prices were much higher.

52. Yes; one-third more.

54. Boston and New York.

55. Boston.

56. Used for painting and for currying leather.

57. Forty and fifty cents per gallon in 1873.

58. Does not appear to.

---

11. *Statement of Chandler Martin, keeper of Whales-Back Light, Whales Back, N. H.—February* 23, 1874, *and January* 9, 1875.

1. Pogy.

2. Most numerous, excepting herring.

3. More abundant in 1874 than for ten years previous.

5. Does not on this coast.

6. From the first of May until the middle of July. The first are generally the smallest.

7. High; they make a ripple and attract birds.

8. Along the shore from the coast of Massachusetts to the coast of Maine.

9. Regular, but more numerous some seasons than others.

10. Nets and seines keep them out of the harbors.

11. Go with the tide.

12. Bays and harbors with strong tides.

13. Shallow. From 4 to 10 fathoms.

14. It does.

15. They are full grown when they visit this coast.

16. They are not.

17. They leave in a body from the first to the middle of October.

18. As they came, along the shore.

29. No.

34. Gill-nets and seines.

35. Gill or float nets are six yards deep and forty yards long. Seines are of different lengths.

---

12. *Statement of Thomas Day, keeper of Seguim Light, Parker's Head, Me.*

1. Pogy.

3. In my opinion they are diminishing.

6. The first school gets on the coast of Maine about the middle of May; the second about the middle of June.

8. These first go and come the same way as the mackerel.

10. Yes, seines tend to drive them from off the coast. There is a fine of $50 for throwing a seine within three miles of the shore; but this is willingly paid when they can take 1,000 barrels of fish in a few hours.

34. Gill-nets and seines and in weirs.

35. Seines are 1,500 feet long and 80 feet deep.

36. There are at present about 75 small steamers besides many sailing-vessels.

37. Each steamer and sailing-vessel will average eight men each.
42. Boiled for oil; the chum is sold for manure.
47. The pogy is worth, on an average, $1.25 per barrel.
57. Oil is worth about 50 cents per gallon.

---

13. *Statement of William S. Sartell, Pemaquid Light-Station, Bristol, Me.—February* 1, 1874.

1. Menhaden or pogy.
3. Diminished.
5. Yes.
6. May 20.
7. They swim near the top.
8. From the South.
10. It does, for they were not seen from this station last summer.
17. September. It is done in a body.
18. They go South.
20. It is a small red seed that floats in the water.
21. South of this place.
34. Seines.
35. Twelve hundred feet long by 360 feet deep.
36. Steamers and schooners.
37. Ten men.
38. All day.
40. It does.
41. Sixteeen steamers and 30 schooners and sloops.
42. Fried out for the oil.
43. Seven factories. In 1873, J. Tar, Bingham & Co., L. Nickols & Co., Union Factory, and three others.
44. In 1873, J. Tarr used 85,000 barrels fish, Bingham & Co. 1,000,000 barrels, L. Nichols & Co. 50,000 barrels, Union Factory 25,000 barrels, and three others 25,000 barrels each.
47. Sixty cents (1874).
48. From three gallons to one barrel.
52. Yes, in the summer.
54. New York and Boston.
55. All over the country.
57. Forty-five cents (1874).
58. Yes.

---

14. *Statement of Alden H. Jordan, keeper of Baker's Island Light, Cranberry Isles, Me., December* 29, 1873, *and February* 9, 1874.

1. Pogy.
2. About 100 per cent. more.
3. Diminished.

4. There was none of any account; in 1861 there was quite a catch in this vicinity, mostly in small boats; since that time the fish have diminished to a great extent.

5. It does.

6. About the 15th of June, and then, about six or eight days after, the main body arrives, the first fish that come being as large as any. They come in schools, one after the other.

7. Swim high in moderate and calm weather; they make a ripple and attract birds.

8. From the west, following the coast.

9. Regular.

10. Yes.

11. They play in on the flood and out on the ebb.

12. They play in the tide about one-half mile from the shore.

13. About 18 fathoms. From 2 to 4 fathoms.

14. It does not.

15. The ground in this vicinity appears to be their feeding-ground. They are all of one size.

16. Not any.

17. About the 20th of September.

18. West.

19. South.

20. Shrimp.

29. No.

31. Never saw any.

32. To a great extent.

33. Not any.

34. Nets are knit of twine; 3½-inch mesh.

35. Length, 25 fathoms; depth, 2 fathoms.

36. Steamers and schooners, from 20 to 30 tons.

37. Four to twenty.

38. Two-thirds.

39. Yes; on the flood.

40. Yes; it makes them swim deep.

41. None.

42. On the spot, or sent to Brooklin, Me.

43. None.

47. Those that catch the fish keep them for bait, or for their oil, in this vicinity.

48. About 55.

49. About all the scrap in this vicinity is put on the ground for dressing.

50. About 3 gallons when the fish are first caught.

51. About 5½ gallons in September.

52. Yes. I think the first fish were caught in 1858.

54. Boston, Mass.

55. Boston, Mass.
56. It has been used for paint for the past thirteen years.
57. Price per gallon, 45 cents. In 1861 it averaged $1.38 per gallon.
58. It does to a great extent.

---

15. *Statement of Washington Olin, keeper of Pond Island Light, near Boothbay, Me., February* 18, 1874.

1. Menhaden or pogy.
2. More abundant than any other fish.
3. Diminished.
5. It does.
6. In May; the main body arrives in July. The July fish are the largest.
7. They swim at the top of the water and make ripples.
8. They come from the south.
10. Tends to scare them.
12. Very near the sea-shore.
13. Generally at the surface.
16. They are not.
17. They leave the coast in the fall.
18. Go south.
31. Worms are sometimes found in them.
33. No disease of any kind.
34. Purse-nets or seines.
35. Length from 200 to 225 fathoms; depth from 15 to 25 fathoms.
36. Steamers, from 75 to 100 tons.
37. From 10 to 15 men.
38. All day, if the weather is fine.
42. Steamed and pressed for oil at Boothbay.
43. Not any nearer than Boothbay; owned by Luther Maddocks.
47. From 40 cents to $1.25 per barrel.
48. Four hundred in May; 100 in August or September.
50. One gallon in May.
51. Four gallons in August or September.
54. Boston and New York.
55. The Southern States.
56. For painting.
57. About 50 cents.
58. Very much, and drives them from the land.

---

16. *Statement of an unknown correspondent, Gloucester, Mass., March* 28, 1874.

1. Menhaden, hardhead, or pogy.
2. About the largest (if not the largest) school of fish that visits our coast.

3. Have not seen much of them for the past eight years, but should think that they had diminished a small per cent. during that time.

4. There are no establishments here engaged in the manufacture of menhaden oil.

5. Do not think it does.

6. About the 15th of May, and are the most plentiful about the 1st of June. The first are generally the largest. Generally two, about one week apart.

7. Sometimes at the surface, and oftentimes they pass along without any show. I should think, from an experience of twenty-five years, that they never go below 5 fathoms from the surface of the water. Their general habit when on or near the surface is to slap—that is, to raise the tail and strike it down on the water. This produces a sound different from any other kind of fish. They, as a general thing, make a small ripple on the water, and oftentimes they can be told by the color of the water which covers them. It presents a yellowish color, as a general thing. Do not attract birds.

8. They come from the south, and, as a general thing, follow along the coast, sometimes near the land, but of late at the distance of from three to twenty miles from land, along the coast of Massachusetts to the coast of Maine. I never heard tell but once of their crossing the Bay of Fundy.

9. Regular and certain; they do not.

10. I think it has a tendency to do so.

11. As a rule, more apt to come to the surface in deep water; in shallow water they go in and out with the ebb and flow of the tide.

13. If not disturbed they would stay near to the shore, but about 5 fathoms when out of sight.

14. It does. Cold easterly winds tend to keep them beneath the surface; warm southwest winds and clear sky appear to put them in a playful mood.

15. Could not say, but should not think they came until the second year; should think not.

16. Never saw any but once in the month of August; about 3 inches in length.

17. In the month of November, by degrees; that is, they pass along day by day until all are gone.

18. They go southward.

19. Could not say, but have heard of them in the month of February on the coast of Florida.

20. Suction, or on the small particles to be found in the water.

21. Never knew, but think where they spend the winter.

23. Never knew it to be.

25. Should think on the bottom.

26. Do not know, but think they remain at the bottom.

28. Not around this coast.

29. Not around these parts.

30. Cod, pollock, and various other kinds; the parent fish does not.

31. Never saw any such.

32. The bluefish is the only deadly enemy.

33. About eighteen years ago they died in large quantities, and were piled along the coast of Maine for miles.

34. Seines and gill-nets.

35. Seines are from 150 to 240 fathoms long and from 10 to 30 fathoms deep. The nets are about 20 fathoms long and 5 fathoms deep.

36. Fore and aft vessels, from 30 to 80 tons.

37. From 5 to 12 to each vessel.

38. Depends on the weather and the fish.

39. Generally more taken on the flood than on the ebb tide.

40. Easterly winds do.

41. About 45 sail for 1873, and about 500 men.

42. In Gloucester, the greatest fishing port of Massachusetts, they are used for bait; but some are carried in ice to George's Bank, and the remainder are slivered; that is, the sides are taken off and head and backbone thrown away, and salted for the mackerel and Grand Bank fishing.

43. None.

47. From \$1 to \$2.50 for fresh, and from \$6 to \$9 for slivers, per barrel.

48. Spring of the year about 2 quarts to 1 barrel; when in good order, last of August, 3 gallons to 100 fish.

50. See question 50.

51. See question 50.

52. Think they do, as a general thing.

54. Boston, Salem, Danvers, and other places.

55. Sold from factories and carried to different places in Maine and Massachusetts.

56. Sometimes used for leather, but more often to mix with linseed-oil to cheat the consumer.

57. About 40 cents per gallon.

58. In pressing out the oil some gets overboard and makes a calm streak on the water; this the menhaden will not cross, so that I think this, if it does not diminish, at least drives them farther from shore.

---

17. *Statement of Capt. F. J. Babson, Collector of Customs, Gloucester, Mass.*

1. The name usually employed by fishermen to designate these fish in the waters of Massachusetts and Maine are hardheads, pogies, menhaden.

2. They are found in great abundance in this vicinity, and apparently exceed in quantity all other fish except mackerel and herring, between which the disparity is not noticeable.

3. They have doubtless decreased within the last ten years.

4. During the past year about 60,000 barrels of round fish were caught by vessels from this district, all of which were used for bait for mackerel and codfish. The side of the fish is cut longitudinally from the head downward, on either side of the bone, while the head and vertebræ are thrown away; the pieces cut off, called slivers, are salted and packed in barrels for bait. Three barrels of round fish will make one barrel of slivers. Nearly all the pogies caught in this district are used in this manner for bait. There are about 800,000 barrels caught off the coast of Maine, all of which are used in making oil. The refuse, or chum, being used for manure.

5. Their numbers doubtless decrease from their extensive capture.

6. The first appearance of these fish in Massachusetts Bay is about the 15th of May, alternating in quantity, and culminating about the 15th of June. The first arrivals are the largest. For a few days they are seen, then disappear, then reappearing in about three days in large quantities.

7. They swim near the surface, and are often seen with their heads out of water going in one direction. Their arrival is known by observation, as they always show themselves, and in moderate or calm weather they can be seen for miles schooling, or breaking water as it is called.

8. They come along the coast from the south, that is, taking Cape Cod as the southern boundary of our vessels' operations, and from thence follow the coast of Massachusetts and Maine as far north as the southern limit of the British possessions, but they are not taken on the British coast. (Under the Treaty of Washington this extensive fishery is now thrown open to British fishermen, when formerly they were obliged to buy pogy bait from our fishermen.)

9. They have not failed to make their appearance regularly for the past thirty years, and always in large quantities.

10. Since they have been taken in large quantities for their oil they have gradually avoided the bays, creeks, harbors, and rivers, where they once resorted in immense numbers, and are now principally taken from one to ten miles from the shore. Some of the fishermen maintain that since the advent of the bluefish (the most destructive fish in our waters) some twenty years ago, the pogies have sought deeper water for their own safety, while others maintain that the bluefish drive the pogies into shoal water; doubtless both statements are at times true.

11. When in deep water, subject to but little action by the tide, they are not apparently affected, but when in close proximity to the shore they will go up rivers and creeks with the tide and come out with it. They naturally tend inshore mornings and go off evenings.

12. Chesapeake Bay, Long Island Sound, and along the coast of New England, are their most favorite resorts.

13. They are found in all depths of water, and usually swim low during easterly winds.

14. In pleasant and warm weather they frequent the surface when the water is warm.

15. They do not breed upon the coast or waters of Massachusetts or Maine, and we have no evidence at what age they become mature. It is rare to see any but the full-size fish, or very nearly so. Usually the fish caught are of equal size, and apparently being of the same age.

16. Young fish have been seen, but at rare intervals, in schools by themselves, in size about half grown.

17. They leave our waters by degrees, beginning about the 1st of October, and by the 30th they are all gone.

18. They follow the coast apparently in the same manner as they come, to the south.

19. They are found in the winter in the vicinity of Cape Henry and Cape Charles, but doubtless they are mostly in the Gulf-stream. They have also been seen in winter on the southwest edge of George's Bank.

20. They feed while in northern waters upon a red bug, or animalculæ, that floats on the surface of the water. This they imbibe by suction, for they have no teeth.

21. The spawning-ground of these fish, so far as the observation of the fishermen extends, is in Chesapeake Bay, Long Island Sound, and the waters adjoining. No indication of their spawning exists in our waters, and in a catch of many thousands there is seldom seen a single fish with spawn in them.

22. There are no indications of the sexes observed while in our water.

26, 28. The young of these fish are seen in the vicinity mentioned as their spawning-ground.

30. Sharks, blue-dogs, porpoises, but the most destructive is the bluefish. Have never heard of the parent fish devouring the young. Whales have been seen in active pursuit of them.

31. No animals are found attached to them while north.

32. There has been no ratio determined.

33. There has never been any sickness or epidemic while in Northern waters.

34. Seines and gill-nets are used in their capture. These fish never take the hook nor pay any attention to bait thrown as for mackerel.

35. The average seines used are 200 fathoms long, 18 fathoms deep, some longer, some shorter. The gill-nets are 25 fathoms long, 6 fathoms deep, $3\frac{3}{4}$-inch mesh.

36. The vessels employed in this district are schooners and steamers. The schooners are wholly engaged in taking them for bait. The steamers are connected with oil-factories in Maine. Schooners are from 20 to 70 tons; steamers 65 tons.

37. About 10 men are required to each vessel.

38. The fish are taken at all times during the day.

39. As most of the fish are taken off the shore, the tide has no effect.

40. When it blows hard the seines cannot be set, as the fish do not show themselves as in moderate weather.

41. The number of vessels in this district is 40, employing 400 men. Capital, $200,000; value of bait taken, $80,000.

42. Those that are used as bait are slivered and salted in barrels; those taken for oil are taken ashore to the factories, where they are placed in immense tanks and subjected to the direct action of steam; they are then put into hydraulic presses, operated by steam and water.

43. There are no factories in this vicinity for making pogie-oil. Other fish-oils are extracted at two factories, owned by A. W. Dodd & Co., and George J. Tarr, both of which are at Gloucester. There are 14 pogie-oil factories in Maine; most of them are in Bristol.

44. The amount of oil manufactured each year at these factories is 1,000,000 gallons; an average of 71,000 gallons each.

45. During the fishing-season, in case they have the fish, these factories could use 100,000 barrels of fish, or at the rate of 700 or 1,000 barrels per day.

47. The companies owning the factories usually own their fishing vessels.

48. Seventy-five fish, when fat, will produce a gallon of oil, that is, in August and September. When they first come on the coast it will take 300 fish to a gallon.

49. The scrap or pumice is the refuse after the oil is extracted from the fish. This is sold for manure, at $15 per ton.

50. About a gallon per barrel is obtained when they first come, say in May.

51. Four gallons to the barrel of fish in September is the average yield.

52. They do.

54. It is sold all over the country: at Boston, Danvers, New Bedford, and most of the large cities.

55. Scrap is used mostly in the South as a fertilizer for cotton and tobacco, and farmers everywhere use some of it.

56. It is mostly used in currying leather, some for painting and for machinery.

57. Average price, 44 cents per gallon.

58. Reports differ; some think there are as many one year as another, but that they keep off shore more; others think they diminish.

I herewith propose to add a few facts and a detailed description of the business, that may be of some value and which are not covered by the questions. The pogie business in this vicinity has ever been conducted on a small scale, as the fish have been taken entirely for bait. There was no large amount of capital invested until they were taken for their oil and manure. Vessels are fitted from this port on the same basis as the other fisheries: The owners of the vessels finding the vessel, outfits, seine, and boats; the crew going at the halves (as it is called), that is, having the proceeds of one-half of the entire catch for their services, the other half going to the vessel. A good vessel with boats

and seine costs about $6,000; the seine alone is worth $1,000, and will last with fair usage two years. They are made from cotton twine, and are preserved by salt and tar. The seine is carried on a small deck on the stern of the seine-boat; this boat is about 36 feet long and 8 feet wide, and is built similar to the old-style whale-boats; they are always towed astern of the schooner, and when a school is seen the boat is rowed outside of them and the seine is thrown over; one end being taken by the wherry or dory in attendance, while each describes a circle around the school of fish until the seine is all overboard and the ends of the seine are joined. As the pogies do not sink as mackerel do, they are thus inclosed in a wall of netting 18 fathoms deep, and then, by means of a small rope rove through consecutive rings on the lower edge of the seine, the bottom is drawn together like a purse, and the fish are thus confined in a basket-shaped net. The surplus folds of the net are then gathered up until the fish are left in a small space like drawing a basket gradually from the water. The vessel is then brought alongside the seine and small dip-nets are used to bail the fish from the seine to the deck of the vessel. Often such large quantities are taken in the seine that the vessel is filled and many of the fish are killed by the close confinement and weight of the others; and when the seine is opened for their release they are mostly dead. This difficulty is obviated if there are other vessels near, who usually take the surplus fish, giving the value of one-half to the successful vessel. After the fish are taken, when they are to be used for bait, they are slivered into barrels and salted; sometimes they are sold fresh; and as the vessels bound to George's Bank use ice to preserve their fish, the bait is placed on ice and thus kept fresh. But by far the principal part is salted and used by mackerel-catchers; this bait is ground into a fine consistency, and is thrown along the side of the mackerel-catcher to *toll* the mackerel to the surface and keep them alongside the vessel. There are about 60,000 barrels of pogies taken by the bait-catchers from this district, and these produce 20,000 barrels of slivers, worth to the producers $4 per barrel. It is observable that these fish are much fatter while on the coast of Massachusetts and Maine than when on the more southern coasts.

---

18. *Statement of Simeon Dodge, Marblehead, Mass.*

JANUARY 9, 1875.

SIR: Your circular of December 20, with letter inclosed, is at hand. In reply thereto, I can see no reason at present to change the general conclusions in my previous communications, although, of course, the statistical portion is undergoing a constant change. I herewith present such additional facts as come within my knowledge.

1. They are known here as hardhead or menhaden.

2 and 3. Greatly diminished. Less abundant than other fish.

4. All that were taken were sold fresh for bait, and would probably not exceed 50 barrels.

5. Probably.

6. About the 9th of May; the main body or smaller-sized ones about July.

7. They swim deepest when they first arrive, although usually with their noses at the surface, so as to be plainly seen by birds, &c.

8. When first seen they move along the coast from the south toward the north; subsequently return toward the south across the bay.

9. Their appearance is regular, but the number constantly decreasing; have never known them to fail for a season.

10. Seining tends to destroy the shoals, and large numbers are killed that are not secured. And this fact *will apply to all shoal as well as other fish,* which, together with trawls, are fast destroying all our fishing business.

11. They move upward with the flow and back with the ebb tide.

12. At the mouth of fresh-water streams.

13. Shoal water, though they have been caught 4 fathoms below the surface.

14. They are usually found deeper when the water is cold, when they first appear.

15. The first shoal are, apparently, mother fish, as the shoals that follow are smaller and younger.

16. The young fish are found in inlets and coves the latter part of August.

17. They leave the coast the latter part of October in a body.

18. Across the bay to the south.

19. Unknown.

20. A reddish substance resembling ground cayenne pepper.

28. They are not. Very few are found in coves, &c.

29. No.

30. The parent fish do not destroy them.

31. Worms are sometimes found in their gills.

32. They are destroyed to some extent by sharks and blue-fish.

33. No.

34. $3\frac{1}{4}$-inch mesh, formerly $4\frac{1}{2}$ inch, showing that the size of the fish has diminished.

35. Seines 150 fathoms long by 12 fathoms in depth are usually the dimensions.

36. Small boats are used here generally, although larger craft from other ports fish within our waters.

37. In larger vessels 10 to 13 hands.

38. At any time during the day.

39. No.

40. No.

41. None employed.

42. Bait for codfish, and tollings for mackerel.

43, 44, 45, and 46. None.

47. $1 per barrel for fresh; $6 for salted.

58. It certainly seems to, although there may be other causes unknown at present. There is one fact which cannot be denied, and that is that these fish, once so plenty, have become almost extinct in these waters.

---

19. *Statement of Eben B. Phillips, Swampscott, Mass., January* 21, 1874.

1. Menhaden; sometimes as pogies.

2. It is the most abundant, except, perhaps, mackerel.

3. It has neither diminished nor increased.

4. There are no establishments in this vicinity.

5. No.

6. In April they appear on the coast of New Jersey; in May they reach Rhode Island and Connecticut; by the middle of May or 1st of June they come here, and early in June reach Maine, the body of them arriving on the coast of Maine early in July. They leave by the middle of September, or first of October, and go south, no one knows how far. The first are not larger than the others. Many schools come in at same time. They are coming for a month, and going for a month, in streams 300 or 400 miles long.

7. They swim high when they come. In the fall they swim deeper, 6 to 50 feet down. They make a ripple. They do attract birds, viz, fish-hawks—not gulls, nor any other bird.

8. They come along shore, as stated in No. 6.

9. Their appearance on the coast is regular and certain; they never fail, except that they do not come close to the shore, and up the rivers, as much as before; they lie off.

10. Yes. And they can be caught better off shore. We don't want the seine to touch bottom.

11. None.

12. In summer from Portland to Mt. Desert they frequent the mouths of rivers—not very shoal waters. They are also found in abundance on George's Bank.

13. Answered above.

14. No, except when the weather is frosty, when they leave. Sometimes, when it is warm and sunny, they come to the surface.

15. We do not find immature fish with mature ones on the breeding-ground. In this they differ widely from mackerel, of which all sizes are found together. I think they get their growth in a year.

16. We never see small fish.

17. The fish leave as above stated, and leave by degrees, moving two or three miles per hour, and at twice that rate when the wind is north-east.

18. They stick to the coast, sometimes following the bend of Cape Cod. Barnstable Bay was full of them last fall on their way south.

19. At the south somewhere; it is not known where.

20. They feed on a sort of slime. They come north very poor and return from Maine very fat. The fish has no teeth. It has a gizzard, and the contents only equal the size of a small shot. They do not eat fish nor any vegetable.

21. They spawn here in August and September.

22. Cannot answer. We always see them in great bodies—not in pairs, or in small numbers. I think their being in great bodies, is some protection against whales, sharks, &c.

23. No, not whitened or colored.

24. Warm water in August and September.

25. At any depth, I think.

26. I suppose the spawn sinks, as all spawn tends to sink.

28. No.

29. Yes, often.

30. Almost all fish eat spawn and young fish. The parents menhaden do not. They feed as above stated. Their spawning further out at sea than formerly, must save the spawn. It used to be cast on shore more than it now is, when we had a high wind.

31. No.

32. Extensively from sharks, horse-mackerel, blue-fish, fin-back and hump-back whales, which always appear in our waters when the menhaden come. The codfish eats them night and day.

33. No.

34. Seines.

35. Two hundred fathoms long, and 10 deep

36. Sail and steam vessels.

37. Eight or 9 men in sailing-vessels—it needs that number to handle a seine; more in steamers.

38. From morning to night.

39. No.

40. I do not know that wind affects the fish, but in a high wind it is impossible to seine. You cannot purse up a seine in a heavy sea.

41. None in this immediate vicinity.

42. The fish are sent to the factories to be cooked by steam and pressed.

43. Joseph Church, Bristol, Me., made, in 1874, 400,000 gallons oil and 4,000 tons of guano; Judson Tarr & Co., Pemaquid, 235,000 gallons oil and 2,500 tons of guano; B. F. Brightman, Bristol, 280,000 gallons oil and 2,800 tons of guano; Round Pond, Bristol, 60,000 gallons oil and 1,000 tons of guano; Muscongus Oil Works, Bristol, 60,000 gallons oil and 1,000 tons of guano; Wells & Co., Bristol, 80,000 gallons oil and 1,200 tons of guano; Union, Bristol, 60,000 gallons oil and 1,000 tons of guano; J. G. Nickerson, Booth Bay, 100,000 gallons oil and 2,000 tons of guano;

Gallup & Holmes, Booth Bay, 60,000 gallons oil and 1,000 tons of guano; Gallup & Morgan, Booth Bay, 60,000 gallons oil and 1,000 tons of guano; Luther Maddocks, Booth Bay, 200,000 gallons oil and 3,500 tons of guano. There are also a number of small catchers along the coast of Maine who make oil in amounts ranging from 50 to 75 gallons.

46. Steam for cooking and steam for pressing cost all complete with seine, boats, and fixtures from thirty to two hundred thousand dollars.

47. In 1873, 60 cents. In former years not so much except at some times during the war.

48. One barrel of *good* fish makes 3 or 4 gallons oil.

50. One or 2 quarts when they first come. They should not be caught until they are fat.

51. Five gallons. It is greatest toward the close of the season.

52. Yes; a great deal more.

53. In about 1850; I was then in the fish-oil business. An elderly lady by the name of Bartlett, from Bluehill, came to my store with a sample of oil which she had skimmed from a kettle in boiling menhaden for her hens. She told me the fish were abundant all summer near the shore. I told her I would give her $11 per barrel for all she would produce. The husband and sons made 13 barrels the first year. The fish then were caught in gill-nets. The following year they caught 100 barrels. From that time and from that circumstance has grown a business as extensive as I have represented.

54. Boston and New York. The whole country buys it for currying. It is exported to London and Liverpool, and thence to all parts of the world for currying, for soap, and for smearing sheep.

55. South, for cotton and tobacco lands.

56. Currying. It is not used for lubricating.

57. Thirty-eight to 45 cents in 1873, 50 cents in 1872; $1.40 was the highest, a war price.

58. No.

---

20. *Statement of Thomas Loring, collector, Plymouth, Mass., January* 24, 1874, *and March* 20, 1875.

1. Pogy.
2. Average.
3. Diminished.
4. Very few.
5. It does not.
6. About the 1st of June.
7. High.
9. Never fail.
10. I think it does.
16. Yes; in September, about 4 inches long.
17. In November. I think by degrees.
19. We think south.

23. The water is whitened.

34. Gill-nets.

35. Forty fathoms long, 4 fathoms deep.

36. No vessels wholly employed in the business; only a few caught for bait.

40. We think not.

41. We do not have any vessels expressly for this business.

42. For bait only.

---

21. *Statement of William Atwood, light-house keeper, Plymouth, Mass., February* 23, 1874.

1. Menhaden or pogy.

6. Formerly about the 1st of May. The first are the largest.

7. They swim high and make a ripple on the surface of the water, but do not attract the birds to any considerable extent.

8. From the south. They work into the sand in bays and coves.

10. Yes.

11. They come mostly on the flood tide.

14. Yes; they prefer an even temperature.

15. They usually keep separate.

16. Yes; and are from one to one and a half inches long.

17. September, in a body.

18. Southeastern.

19. They spend the winter off Virginia, the Capes of Delaware, and in deep waters in the Gulf.

20. Suction.

31. No.

32. Very much.

33. Not on this coast.

34. Gill-nets and seines.

35. The gill-nets are from 15 to 20 fathoms long, and from 4 to 5 deep. Seines vary; are much longer than nets.

36. Propellers, steamers, and schooners, varying from 50 to 100 tons. Beside these, many small boats are employed on the eastern coasts of Maine.

There are no oil manufactories here.

Within the last ten years, these fish have diminished to such a degree that they are almost extinct in this vicinity. It is supposed that the cause of their leaving here was on account of their being frightened by the seines being placed in deep water. We hear that they are taken quite abundantly on the north coast of this State and in Maine.

22. *Statement of Heman S. Dill, Wellfleet, Mass., January 9*, 1875.

1. Pogy or hard-head.
2. They are sometimes very scarce.
3. Diminished.
4. In 1873, I do not know. About six thousand barrels in 1874, in this bay; there is no sale for them in the spring here.
5. I think not.
6. About the middle of May; they are small in the spring and large and fat in the fall.
7. They swim high; are seen in shoals.
8. They come from the south.
9. Quite regularly, about the same time of the year.
10. I think seines are a damage; gill-nets do no harm.
11. The ebb tide they show themselves the most.
12. It seems to me that shoal water or eel-grass bottom, or close in shore, are their favorite localities.
13. You see them in all depth of water.
14. I think it does; they will not stay in cold or warm water; I think they will stay in cold water the longest.
15. We find those of different ages together.
16. They are seen quite plentifully here in August and September, from three to five inches long.
17. They leave by degrees, and are not all gone until September.
18. They leave by passing to the east of Cape Cod.
19. Somewhere in the South, or near the edge of the Gulf.
20. Some small shrimps of a red color we find inside.
21. They spawn here in May or June.
22. They are generally all together, as far as I know.
23. I never saw anything like it.
24. Quite a low temperature.
25. From three to five fathoms in this bay.
26. They are, I think, attached to stones or grass.
28. They are found here in considerable abundance sometimes; I have seen them in shoal water for two months. The blue-fish then drove them out, or they would have remained there for two months longer. They grow from two to three inches while in this shoal. I have noticed them grow from day to day.
29. It does, sometimes.
30. I think most kinds of fish devour them. I think crabs destroy a great many.
31. I never saw anything of the kind.
32. Blue-fish will drive them into creeks and bays, and finally drive them off the coast entirely. They used to stay here all summer in Barnstable Bay; now they stay but three or five weeks, in May and in the first part of June.

33. I never saw anything of the kind.

34. Seines and gill-nets and weirs.

35. The gill-nets are 40 yards long and 6 yards deep.

36. There are no vessels employed anywhere here.

37. The men stay on shore and arrange their nets and the weirs. There are plenty of them here; one weir caught 4,000 barrels in one night this fall.

38. In the first part of the day; sometimes all day.

39. At low water or slack tide.

40. I do not think it does.

41. There are no vessels employed here.

42. Some sliver them for bait; some try them out for the oil, and send it to Boston.

43. There are a few small places here; J. Sparrow, P. Smith, I. H. Horton, and some other places around the bay.

44. Not over 20 barrels; they do not carry it on only in the fall.

45. * * *

46. About one hundred dollars; that is, for press, kettle, house, and fixtures.

47. Fifty cents per barrel. The same price in other years.

48. It takes one barrel to make three gallons of oil.

49. About 5 barrels.

50. Three gallons, I believe, is the least.

52. Yes.

54. Boston.

55. Sometimes it is used here and sometimes it is sent to Boston.

57. In 1873, 55 cents; in 1874, 33 cents.

58. If there was no blue-fish I could tell better; there are not half as many now as there were. There used to be plenty all summer; now there are only a few during that season. I have been in the fishing business for forty years. There are not so many of the sort of fish referred to now as there used to be. I have seen, in this vicinity, the water alive with them; the cause of their scarcity at the present time is the prevalence of bluefish. The pogies stop for a short time only. They pass here in the spring bound north; in October they return again, and stay here about a month. They do spawn here in the spring. I have seen them here five inches long. I have seen barrels of them in the weirs; they would stay in there for two months; the bluefish would keep them in. I think bluefish are their worst enemies. The weirs use up all kinds of fish; one weir caught four thousand barrels of pogies and hardheads in one night this fall. To sum up the whole matter, there are not half so many pogies as there used to be. They do not stop here long enough for us to make a business of catching them. I think seining is a damage to all fishing.

23. Statement of David F. Loring, Highland Light-Station, North Truro, Mass., March 2, 1874.

1. They are called pogies.

2. They are full as plenty from the last of April to the middle of May as any fish that I know of; during that time they are passing in by the cape into the bay, coming from the South. They follow the shore down to the coast of Maine. Whether they go farther to the eastward than the coast of Maine, I do not know; but presume they do certain parts of the year.

3. Apparently not one-half as plentiful as they were ten years ago.

4. There are very few taken at this part of the cape for their oil; about all that are taken are what the fishermen catch for bait for catching codfish, dogfish, &c.; probably all that are taken by the fishermen during the year at this place and Provincetown does not exceed 2,000 barrels. I believe there are a few establishments, for extracting the oil, farther up the cape at Eastham and Dennis; the number of them, and the quantity of oil they get, I do not know.

5. The opinion of people generally seems to be, that they will become extinct in a few years if they continue to be taken for the oil.

6. From the last of April to the middle of May.

7. They first make their appearance in large schools on the surface of the water.

8. I do not know how far to the south they strike the coast when they are coming to the North in the spring. They come in by Block Island, and come through Vineyard Sound, or Martha's Vineyard (so called), as they catch thousands of barrels in the fish-weirs that are built along the north shore of the vineyard. After passing by the cape in the spring, they frequently make their appearance in Cape Cod Bay, through the summer, with the bluefish chasing them; where they come from it is impossible to tell. Whether they come from the eastward, or whether they are new bodies come from the South, I do not know. I have seen hundreds of barrels of them lying along the shore in the western part of Provincetown Harbor that were driven ashore by the bluefish.

9. I do not know as there is any great difference in the schools from year to year, but they *are* decreasing because so many of them are caught for their oil. I presume there has been years when they did not make their appearance, but not within my recollection. I think they are very regular in their habits.

10. I do not think the use of set nets makes any change in their movements, as they are used for catching the fish in the night; but I think the use of the seine has a tendency to frighten them. I know that seining does frighten mackerel, and do not see any reason why it should not frighten pogies.

11. Very seldom see them schooling on the ebb-tide; but as soon as the tide turns flood they commence to school on top of the water. I

have seen the surface of the water literally covered with schools on the flood-tide, while on the ebb there was hardly a fish to be seen. I have seen them under water on the ebb-tide, two or three fathoms down, in schools; but they move very slowly until the tide turns flood; then they school up on the surface of the water, and are quicker in their movements. I have seen them in the fall of the year, when not schooling; but whether schooling or not, they generally play on the surface of the water, except on the ebb-tide.

12. Around the islands and harbors on the coast of Maine.

13. During the summer season generally find them very near the shore, near the surface of the water or a few feet below.

14. It does not.

15. Never noticed young fish with the old ones; very seldom see the young fish after the first year until nearly full grown.

16. Generally see the young fish in October; they are then about three inches long.

17. They commence to move south about the first of October; leave the coast by degrees.

18. I do not think the main body follows the coast in the fall, after passing Cape Cod, as they do when they come north in the spring. I believe the main body, instead of going through Vineyard Sound and following the coast, go out through South Channel and go wide off shore, but presume they strike in on the coast farther south.

20. What the fishermen call cayenne, a sort of fine, red substance floating in the water. Mackerel feed on the same.

21. I think, from observation, they spawn where there is plenty of eel-grass, in localities where they are not apt to be disturbed by bluefish. Their spawning season is about the last of June.

22. I have seen them when they were spawning; they get together in bunches, from twenty to five hundred in a bunch, more or less, in shoal water, over a body of eel-grass, and then swim around in a circle, pressing against each other as they swim. I suppose they deposit their eggs on or among the eel-grass.

23. It is not.

24. Do not know the temperature of the water, but when they spawn the water is quite warm.

25. Where I have seen them spawning it would not ebb quite dry at low water.

26. Presume they become attached to the eel-grass.

27. Do not know how soon they hatch after being deposited, but probably not a great while, as in October the young fish are from three to four inches long.

28. When they make their appearance in October they are very plenty. I have seen the fishermen catch them with dip-nets, for bait. They act very much like the old fish, being in schools or bodies. I never happened to notice them anywhere except in Provincetown Harbor.

29. I never noticed it to be so.

30. I cannot say positively whether the parent fish devour their young or not, but think not; there are, however, many of their eggs destroyed by fish that live on or near the bottom of the sea, such as flounders, sculpins, perch. Sharks and bluefish destroy many of the young fish.

31. Have never seen anything of the kind.

32. Probably the sharks and porpoises destroy many of them, but bluefish are their worst enemy; they destroy an immense number of them every year.

33. Never knew or heard of any disease among them. I have seen them in the mouth of the Merrimac River in immense quantities, schooling; they are probably destroyed in immense numbers along the coast every year by the fresh water coming down the river.

34. Set-nets and seines.

35. The nets are from fifty to eighty yards in length, and from fifty to a hundred meshes in depth; the meshes are from four to four and a half inches in length.

---

24. *Statement of David F. Loring, Cape Cod Light-Station, North Truro, Mass., February* 23, 1875.

1. Pogy.

4. Do not know the number of barrels taken during the year 1873, probably not over a thousand in this vicinity; but during the fall of the year 1874 there was some thirty thousand barrels taken by small steamers with seines. These steamers belong to a company in Fall River, Mass. This company has a large establishment or oil-factory at Booth Bay, Me., where they carry on the business very extensively during the summer season. After the pogies leave the coast of Maine and start south the steam seiners follow them. After leaving their establishment in Maine in November, 1874, and while crossing Massachusetts Bay, the steamers took a fresh breeze and came into Provincetown Harbor; and in going out of the harbor to go around Cape Cod, after the storm, they fell in with pogies in the bay, and took 30,000 barrels in four or five weeks. I believe the fishermen in this vicinity have an idea of going into the business quite extensively the coming season; it will probably be the beginning of a large business.

10. It is doubtless a fact that these fish are driven away from the shore by the use of seines, especially in localities where the seining business is carried on extensively; as, for instance, the coast of Maine, where, a few years ago, the seiners could get all they wanted close in along the shore; now they have to go from thirty to fifty miles off-shore to get the fish. I am informed by old fishermen, who have been engaged in different kinds of fishing on the coast of Maine for the last fifteen or twenty years, that while these fish do not go in along the shore as they used to, they are very plentiful off-shore, but not as plentiful as they were ten years ago; and they agree with me that it is the seiners

that scare them away from the shore, and that they are fast diminishing in number.

21. I have seen them while spawning in the harbor at Provincetown. They get where there is plenty of eel-grass, in from one to three fathoms of water.

22. They get together in bunches or small schools, a barrel or two, more or less, in a school, and swim in a circle pressing against each other.

23. It is not.

50. When they first make their appearance on the coast in the spring of the year they are very poor. I think they will not average more than two quarts of oil per barrel of fish as they are taken from the seine.

51. About four gallons oil to a barrel of fish in November.

58. If it is a fact that these fish are scared away from the shore by the use of seines, and also that these fish do deposit, and if it is natural for them to deposit their spawn on seaweeds and rockweeds along the shore, and from my own observation I think they do, it then follows that they are driven away from their spawning as well as their old feeding grounds, and, as in regard to salmon and other fish that have been driven away from their natural spawning-grounds, they naturally will diminish.

---

25. *Statement of Josiah Hardy, 2d, Chatham Mass., February* 17, 1874, *and January* 9, 1875.

1. Menhaden or pogy.

2. They are more numerous than any other fish.

3. As to their diminishing within the last ten years there have been various opinions; but my opinion is, nor do any now deny it that they are less than they were in years previous to this period. These fish used to enter our bay and line the shores and fill up our inland bays and ponds in immense quantities even to their own suffocation. About the year 1832 they were so numerous on and about this coast, and filled our harbors and the mill and oyster ponds so full they suffocated, and thousands of barrels of them drifted on shore. So many were they, that the inhabitants of this town were summoned to bury them lest a pestilence might arise. The same thing occurred a few years later; then there was no use for them, but they were used for dressing on the land. Since that time, as well as then, any quantity could be had for this purpose.

4. For the last five years about 3,000 barrels each year.

5. Between 1835 and 1840 the mackerel fishermen began using fish for bait, and large quantities were seined for this purpose. Since that time they have diminished to such a degree that very few have entered our harbors and ponds during the last few years. The most of those

which do enter remain through the season. These menhaden are only on their way to the eastern shores, coming from the west when they strike this bay. They come in large schools, and are followed by numerous sea-birds.

6. They have been caught in our bay as early as the 15th of April, but they generally come about the 1st of May.

7. It depends upon the wind. They are generally seen in schools, and they attract sea-fowl.

8. They come from the westward through Vineyard Sound and around Nantucket Island. They come in shore at high water; at low water they keep in the channel, which is from three to seven fathoms deep. I do not think the depth of water affects them very much. They are as regular in their course and movements as a flock of sea-fowl. When one is frightened, they all start; if one turns, all turn; if one goes down, all follow. They have one peculiarity for which we cannot account. Sometimes for hours not a fish can be seen, and then suddenly they rise to the surface and the water is full of schools, sometimes swimming in a circle and sometimes headed in the same direction.

9. I never knew them to fail.

10. Yes.

11. At high water they enter the rivers and follow up into shoal water; on the ebb, they go off into deep water.

12. Rhode Island, Chatham Bay, and the eastern shore of Maine.

13. They school in any depth, and generally near the surface, unless attacked by some enemy.

14. Yes; during northerly or cold winds they swim deep, while during southerly or warm winds they come to the surface.

15. They do evidently mix with fish partly grown.

16. They are in July and August. When some schools get into our inland ponds and stop through the summer, we see the young ones about two inches long and shorter.

17. The fish pass here from south in the latter part of September and first of October. All move about the same time.

18. They follow the shores of Cape Cod.

19. On the southern coast.

20. They apparently live by filtering the water through their gills.

22. They go in large schools, bnt are never known to pair.

23. No.

29. The oldest pogy fishermen say they never saw any spawn in them, but have seen what they called young pogies.

30. They are a prey to sharks, dogfish, squid, codfish, bluefish, halibut, and porpoises.

31. Nothing of the kind was ever seen on them here.

32. The bluefish are their great enemy, and they leave when this enemy comes.

33. I cannot find a man who ever saw a diseased menhaden.

34. Weirs and gill-nets.

35. Twenty-five feet deep and of different lengths, with pounds or traps at the ends. Gill-nets are 115 feet deep. Sweep-nets are 150 fathoms long and 25 deep.

36. There are no vessels in the business.

37. Ten men to a seine or weir.

38. Four hours each day.

39. More on the ebb than on the flood.

40. It does. The warm southwest winds are the most favorable.

41. There are none.

42. They are sold to the Gloucester codfish fleet and to spring-mackerel fishermen for bait.

43. There is no oil establishment here.

47. About $1.50 in 1873.

48. The season makes a difference. In the spring they are very poor and in the summer and fall very fat.

55. A guano factory on Vineyard Sound.

58. It does not diminish them perceptibly. We have in our bay (1875) thirteen fish-weirs within twelve miles, which are set from the 15th of April until the 1st of June. These weirs are set in from two to five fathoms of water. We catch all kinds of fish, for if the leader of a school falls into our traps the rest follow, and thus tons of fish of all kinds are taken.

---

26. *Statement of Alonzo Y. Lothrop, Hyannis, Mass., February* 18, 1874, *and January* 1, 1875.

1. Pogy.

2. Favorably.

3. Greatly diminished.

4. Not many in the immediate vicinity; large numbers east and west.

5. It does, apparently, in this section.

6. In May and September.

7. They swim high and make a ripple; attract sea-gulls and other birds.

8. From the Gulf Stream. They follow up rivers and bays. Have caught them in "dip-net" two miles up Shoal River in two feet of water.

9. Regular and certain.

10. No.

11. All fish more abundant in this section on "flood."

12. From New York to Maine, near shore, rivers, bays, and bends.

13. Shoal water.

14. Leave the coast in cold weather.

15. Yes.

16. Never noticed. Have seen resemblance in smaller fish.

17. In September or October. Should say in a body.

18. Southern.

19. In warm water; probably in the Gulf Stream.
20. Friars, shrimp, and minnows.
22. Think they mix indiscriminately.
23. I never saw the water colored.
26. I think they float in the water until hatched.
28. Not abundant in this section.
29. Yes.
30. Sea-gulls and other birds; besides sharks, dogfish and bluefish.
31. Have noticed quantities of crabs in same seine with pogies.
32. They suffer fearfully.
33. Have noticed them lying dead on the shore. I suppose they were carried up by shoal water or by sea-weed.
34. Purse-net with small mesh.
35. Various. Some 1,000 yards long and 6 fathoms deep.
36. Steamers, schooners, and sloops.
37. Ten to thirty.
38. Morning.
39. Flood.
41. None in immediate vicinity.
42. Mostly to oil factories.
43. None; one at Wood's Holl.
47. From 30 to 50 cents per barrel.
48. One barrel, about.
50. One gallon.
53. Until within a few years pogies were used by mackerel catchers for bait, ground in bait-mill on board of vessel, and fed out to this class of fish (mackerel) to raise them to surface of water. They are then caught by hook and line. Within a few years oil factories have been established, taking in a large territory, and carried on on a large scale at the present time.
54. Cities.
56. Painting purposes.
58. I should say they had not diminished.

Menhaden, or pogies, as they are commonly called in the Eastern States, were found in unusually large quantities during the year 1874, apparently an increase in their numbers. One steamer alone carried into Linniken's Bay (near Booth Bay, Maine) nearly 25,000 barrels. Taking into consideration the large number of vessels of various kinds connected with the business, immense quantities of these fish must be used up yearly, but still they come.

---

27. *Statement of William S. Allen, Nantucket, Mass., January,* 1875.

1. Menhaden.
2. Comparison small.
3. No observable change.

4. About 12 barrels; by lobstermen for bait; none previously taken.

6. October; all arrive nearly at the same time, dividing into, say, four schools, all seen at once.

7. Mostly high; make a ripple; attract birds.

9. Since first noticing them their appearance has been nearly regular in time and numbers.

10. Their capture is not pursued here.

11. Seen mostly on the flood.

13. Unknown; both high and low.

14. Yes.

17. At the first change to coldness—in a body.

20. Animal.

23. Sleaked, or greased.

26. Probably float.

30. Bluefish.

40. Yes.

41. None.

42. All use baiting purposes.

43. None.

56. A quantity is used in paints.

58. Probably.

61. January 3, 1875.

---

28. *Statement of R. C. Kenney, Nantucket, Mass., January* 21, 1874.

I have the honor to acknowledge receipt of your communication of the 20th ultimo, relative to "Statistics of the Menhaden Fisheries, &c.," and herewith transmit such information as I have been able to obtain on the subject.

1. Pogy.

2. More numerous than any other kind of fish.

3. They vary from year to year, but as a whole, for the past ten years remain about the same.

5. It does not.

6. They appear about the 1st of May, or if the season is early, a little sooner. Are most abundant in June and July; the last run are the largest and fattest.

6. They gradually increase in abundance from the first.

7. Swim on the surface, causing a ripple, and do not appear to attract birds as other fish do.

8. When they appear in *our vicinity* it is from the direction of Sandy Hook and the Jersey shore. By *our vicinity*, I mean from the entrance to the Vineyard Sound, around Cape Cod.

9. Their appearance in large numbers is not regular or certain. When they fail to appear for a season the next year is usually a good one;

above the average. I think the prevalence of strong southerly winds favorable to their return.

10. It does not.

11. The tide has no apparent effect upon them.

12. Cannot name any definite locality.

13. Have seen them in deep and in shoal water. They usually track the shore.

14. They appear to prefer warm weather. A cold turn will drive them off.

15. When taken in any quantity there appears to be a mixture of old and young.

16. We frequently see them in the fall of the year, from 3 to 4 inches in length.

17. They commence leaving the coast about the 1st of October, and disappear altogether in November.

18. They return by the same route that they came.

19. I am not certain but think they go to the edge of the Gulf Stream.

21. Judging from the number of small fish seen I should say they spawned around our shores in June and July.

26. I think they sink to the bottom and become attached to stones, &c., like other spawn.

29. Yes.

31. Have sometimes seen lamprey eels attached to the outside.

32. Sharks, sword-fish, porpoise, and bluefish are very destructive to them.

33. I know of none.

34. Purse-nets, gill-nets, generally; sometimes by sweep-nets and fish-wears.

35. Purse-nets are from two hundred to three hundred fathoms in length and from fifteen to thirty fathoms in depth. Gill-nets are about seventy-five fathoms in length and from two and a half to three fathoms in depth.

36. In this vicinity sail-boats of about 5 tons' burden are used for setting the nets.

37. For a purse-net about eight men are required; for a gill-net one man with a dory; for a fish-wear from seven to eight men.

38. The gill-nets are set nights; the others through the day.

39. No difference.

40. I think not.

42. About one-half are put on board our fishing-vessels to be used as bait in the cod and mackerel fisheries. The balance are sent to the factory at Woods Holl, Mass.

43. The nearest factory is at Woods Holl, Mass. The owners are unknown to me.

47. The price per barrel, for some years past, has been from fifty to seventy-five cents, as taken from the nets.

52. They do.
56. Used for tanning purposes.
57. From forty to fifty cents per gallon.
58. I cannot see that they diminish under any circumstances.

---

29. *Statement of C. B. Marchant, collector of customs, Edgartown, Mass., January* 13, 1875.

1. This species is known in this locality by the name of menhaden.
2. They are more abundant here than any other species of fish.
3. Their numbers have not materially decreased or diminished during the last ten years.
4. There were about 5,000 barrels taken here in 1873; in 1872, 10,000 barrels. The following companies and persons are engaged in their capture: Jason Luce & Co., Richard Flanders & Co., Prince Stewart & Co., Edwin A. Luce, Thomas Norton, Edmund Cottle, and John Look.
5. Their capture does not affect their abundance.
6. They come on the coast the 1st of May; other schools at intervals to the middle of June. The first caught are not the largest taken during the season.
7. They swim near the surface, ripple the water, and attract birds.
8. They enter these waters from the southwest.
9. They frequently fail for one or more seasons, but return again in usual numbers.
10. Pounds used for their capture appear to scare them.
11. More fish are caught on the first of an ebb-tide than at other times.
12. Their favorite locality in this vicinity is the Vineyard Sound.
13. They are found in greatest numbers in deep water near the shore, and on the surface of the water.
14. They seek water of the highest temperature.
15. All fish seen are of full growth, or nearly so.
16. Young fish are not often seen on this coast.
17. They leave this vicinity about the middle of July, and return in small numbers in November.
18. They are moving to the eastward.
19. Unknown.
20. Unknown.
29. The spawn is often found to escape when captured.
30. The bluefish destroy the spawn; the parent fish is not known to devour them.
31. Crabs, worms, &c., not observed attached to gills or mouths of these fish.
32. The enemies of these fish do not perceptibly diminish their numbers in this locality.

33. No fatal epidemic or disease has been observed among these fish.
34. The method of their capture in this locality is in pounds.
35. The dimensions of these pounds are about 1,200 feet long by 28 feet wide.
36. No vessels are employed in their capture.
37. Forty men are engaged in their capture.
38. These men are employed all the time during the season of fishing.
39. The fish are taken principally on an ebb-tide.
40. A southwest wind the most favorable for their catch.
42. The fish are sold to vessels on the spot for bait.
43. None.
47. The price per barrel, in 1873 and previous years, averages 50 cents.
58. The catch of these fish does not appear to diminish their number.

---

30. *Statement of Jason Luce & Co., North Tisbury, Mass., January* 6, 1875.

1. Menhaden.
2. They exceed others.
3. Diminished.
4. Five thousand.
5. No.
6. About the 1st of May, and the first are the largest.
7. They swim high, make a ripple and attract birds.
8. They come from the south and go west.
9. They are sure to come.
10. I think not.
19. South.
20. Suction.
21. South, in the winter.
30. Bluefish. No.
31. I never saw anything of the kind.
32. Bluefish make great havoc with them.
34. Purse-nets.
43. Pacific Guano Company.
50. Least in June.
51. Greatest in November.
56. Used for paint.
58. No.

---

31. *Statement of Gallup, Morgan & Co., Groton, Conn., December* 28, 1877.

We have two steamers; the Daisy and the John A. Morgan; tonnage respectively, 66, 87; 14 men each crew. Length of seine, about 230 fathoms; depth, 25 fathoms. Number of barrels of fish taken, 24,000.

32. *Statement of Luce Brothers, East Lyme, December* 4, 1877.

We have one steamer, 76 tons burden; 9 sloops, 19 tons burden; 4 crews of 12 men each. We employ 40 men in our mill. Seine, 150 fathoms long, 18 fathoms deep. We have taken 23,800,000 fish; made 2,400 barrels of oil, or 103,200 gallons.

---

33. *Statement of Daniel T. Church, Tiverton, R. I., March* 23, 1874.

1. Menhaden.

2. There is no fish so plenty in Narragansett Bay as menhaden if we take several years as the standard; but if we should take years as they come, and name each year separately, it would be different. For instance, during 1871, 1872, and 1873 scup appeared in Narragansett Bay in immense quantities, and there is no doubt in my mind but that there has been during the years named more of them than menhaden; but for a number of years preceding scup were scarce.

3. Menhaden has, on an average, been plenty in Narragansett Bay for the last ten years. But for about ten years they were so scarce that some of the fishermen left the business. It is my opinion that when bluefish were plenty they destroyed such large quantities that there was a vast diminution, and it was seriously feared that they were to disappear; but since the bluefish have grown scarce menhaden have grown plenty, and 1871, 1872, and 1873 have been great years in the business for bluefish. Sharks and a large fish called horse-mackerel have been for some unknown reason scarce. The horse-mackerel spoken of does not frequent the waters of Narragansett Bay, but are found east of Cape Cod.

4. Taking for a basis of estimate that there are eight menhaden factories on Narragansett Bay that used 20,000 barrels each, it would make the number of barrels caught during year 1873 about 160,000, and I think the above estimate about right.

5. We do not think that fishermen have any perceptible effect on menhaden, for it is a fact well known that a few years back they were scarce and it was generally conceded that the business was a failure, and some left the business because of the scarcity, and fish-gear, such as boats and seines, were sold for less than fifty cents on the dollar. But since then they have been plenty, and the year 1873 has been a year of surprise to all, for the sea has been one blanket of menhaden from the Chesapeake to the Bay of Fundy.

Menhaden strike the coast not far from the first of May, and there is not many days' difference between their arrival on the coast of Virginia or Maine. It is the opinion of those best informed that menhaden go to sea in winter and come in during the spring. I once had a brother in

Virginia fishing, and at the same time I was at Seconnet fishing, and there was not three days' difference between their arrival in the Chesapeake and the Narragansett Bays. The strongest proof of the correctness of the above theory is that there is a body of menhaden from one end of the coast to the other during the whole season?

7. It depends upon the weather. Fish make a ripple in the water. When it is warm they generally are near the surface and when it is cool they swim deep.

8. It is my opinion that the fish go square out to sea from one end of the coast to the other, although their general course when first seen is toward the east. But if they all went east, how is it that so many are from one end of the coast to the other during the whole season.

9. I have never known a season that they have failed to make their appearance. Their time of arrival varies as the season is warm or cold. I have been at Seconnet for seventeen years in succession, and every season they have come sooner or later, but in different quantities, for some seasons they are much more plentiful than they are others.

10. The nets and seines do not scare them from the shore, for Narragansett Bay has been the theater of their greatest capture for forty years or more, and they have been more plentiful than ever before for the last few years. I have seen a school of fish set out ten times in succession in deep water and they would dive under the seine each time, but when they came to the surface they would not be ten feet from the seine, and they would lie still until we got ready to set; when the seine was around them they would dive again.

Fish will drive menhaden but man never does, except by use of powder; they are sensitive to a jar, such as hitting the deck of a vessel with an ax; even so slight a jar as the dropping of an oar or the careless slat of a rung on the gunwale has sent a school of fish off at full speed.

11. They drift with the tide sometimes, and then again they swim against it. I have seen them in Dutch Island Passage, which is the western entrance to Narragansett Bay, drift in and out with the tides as regular as it ebbed and flowed. At the first of the flood they would come in and work up as far as Rocky Point, and when it made ebb they would drift down near Narragansett Pier.

12. I know of no favorite places. We hear of them on George's Banks, on Nantucket Shoals, off the coasts of North Carolina and Virginia. I have seen immense schools of them off the coast of South Carolina, and we all know they are in all the rivers, bays, and creeks from South Carolina to the Bay of Fundy during the summer months.

13. I think they care nothing about depth of water, for they are found in large quantities in deep and shoal waters. We catch large quantities on the coast of Maine in 50 fathoms, and even in 100 fathoms; and at the same time there are large amounts of them in the rivers and bays in shoal water.

14. The temperature of the water does seem to affect them; they do

not seem to like cold water. When it gets to be cold weather they leave, and I reason from this that the air makes the water cold, and then they start. But they go onto the coast of Maine, and keep in the cool, deep water, when, if they liked, they could soon be in warm and shoal water. Why they do so is more than I know; but there seems to be difference of habit, for some stop in the deep and cool water while others go into the shoal and warm water.

15. I know nothing of their habits or laws of breeding, but I do know that we rarely see any of them with spawn in them, and when so found it generally is in the fall. But we have abundant evidence that they do spawn in this bay, from the fact that often we take in our nets bushels of their spawn, and also during some seasons there are large quantities of small fish about the size of sardines. They are always seen in the fall. We know nothing of one or two year old fish; they are either full grown with us or small. But there are different sizes of fish, as we find by our nets, for we use a mesh $3\frac{1}{4}$ inches large, and sometimes we catch a school that "gill" in them, although not often. We take schools of fish that are large and overgrown, but we generally think it to be due to the difference in their feeding grounds.

16. Now and then there are plenty of small menhaden in Narragansett Bay, but it is the exception instead of the rule. I never saw any young menhaden east of Cape Cod, and I have asked a man that has fished constantly for menhaden east of Cape Cod for about ten years, and he says he never saw any. I have seen plenty of them south of Narragansett Bay.

17. It is hard to tell when the fish leave the coast, for we can fish with our purse-seines and have good fishing if it is good, warm weather, but if it comes on cold, the fish vanish, and to all appearances they are gone, for they do not show on the surface of the water; but the gill-nets will take them long after, and they have been so taken as late as New Year's, when they are quite plenty; this shows that they are not gone at that time. Who knows but what they are close by all winter?

19. We don't know where they spend their winters, although I have seen large quantities off the coast of South Carolina and North Carolina during the winter months.

20. I don't know the nature of their food, except we think it is a small live something in the water, for they go about with their mouths open, as if sifting or straining the water for food. We call it brit. It must be something of great fattening properties, for they fat rapidly when they arrive on the beds of it that lie off the coast of Maine.

21. I know they spawn on Narragansett Bay.

28. They are abundant some seasons in this bay, but not always. I have seen millions of barrels, about the size of sardines; and on the coast of North Carolina I have seen them for miles square so plentiful, about the size of sardines, that you could hardly move a boat through them, and an oar among them would fall down about as fast as

a stick would in thick molasses. The havoc that gulls and fish make among them is fearful when they are together in such bodies.

32. They are the bait or food of most every fish in the sea. Bluefish is the menhaden's great enemy, for when they attack in large quantities, and they used to come apparently about as plenty as the menhaden, they annihilated vast schools of them. Instances are known when they came into this bay in such force that they drove them on shore in large quantities, and in a short time most there was in the bay would be destroyed. The record here is the same from one end of the coast to the other. Cape Cod Bay was cleaned out, as were the rivers and bays on the coast of Maine, and the destruction was so large in some parts of Maine, that the people had to bury them from the fear of a pestilence. The same story is told at Long Island, and also on the Connecticut shore. The sharks destroy them. I once saw a body of them destroyed or scattered in less than one hour. This was off Seconnet. They were lying there apparently undisturbed, when suddenly a large school of sharks appeared among them, and the havoc was fearful. One gang of fishermen had their seine in the water, and the sharks destroyed it; they were so ugly, that they would grab an oar in the water as quick as they would a fish. Porpoises are fond of them, and they can do as much destruction as any fish, but they are not often seen around here. Codfish also catch them.

33. I know of no epidemics, but I have heard often from old people how that years ago most all the menhaden in the sea and in the bays died, and for a year or two they were scarce.

34. Purse-nets at present are used mostly to capture them.

35. About 180 fathoms long and 80 feet deep, although some are 250 fathoms long and over 100 feet deep; while others, on the other hand, are not over 75 fathoms long and 50 feet deep. The length and depth of seines depends on the depth of water and the kind of fishing.

36. Steamers and sailing-vessels. The largest steamers are 70 tons; the smallest, 25 tons. The sail-vessels usually are about thirty tons, new measurement, and are used generally to live in. They have tenders to take the fish to market; said tenders are of an average capacity of two hundred and fifty barrels, but latterly they are built larger, and there are some in use that will carry six hundred barrels. Besides the tenders and vessels, there are the purse and mate boats, which carry the seine and men. These boats are about twenty-four feet long and six feet wide, and take one-half of the seine each; they are then started from a central point and row around the fish.

37. The sailing-vessel has a captain, who manages the vessel when the men are absent taking the fish. The purse-crew, which man the purse and mate boats, consists of six or eight men. The purse-boat contains the captain of the gang, and the mate-boat has the first mate. Each boat has a seine-setter and two men to row around the fish. In addition to the above men, most of the gangs have a fish-driver in a

small boat, who keeps close to the school and guides the gang in setting for them. The fish-driver makes the seventh man. Some gangs have a man they call a striker. Generally, he is an apprentice, who goes for small wages to learn the business. He makes the eighth man. To recapitulate: A purse-gang, for either steamer or sail-vessel, consists of from six to eight men, and the different make-up of gangs arises in different ideas of different gangs. Each boat has to have a seine-setter and two men to row. Steamers have the same crew as vessels, except they have no tenders, thereby saving that expense. To illustrate: Suppose a sail-vessel has a purse-gang of seven men and three men to run tenders; that makes ten men in all as sharesmen. In a steamer the three extra men are dispensed with, and the steamer takes their part for the extra expense of coal and machinery, but the men's shares are the same on an equal amount of fish. The captains of the steamers manage them when the crew are absent catching the fish.

38. All parts of the day are used in taking them, but the moderate part is preferred.

39. The tide is watched in catching fish. Generally, slack water is the time when they can be taken the best, for at that time the seine is not scraped over the bottom, thereby escaping the chances of catching against obstructions and tearing. Cases have happened where seines have been totally lost, and hardly a day goes by when one or more are, in fishing language, ripped up; and sometimes it takes a week's steady work to mend them. When the water is still, the seine hangs better in the water. It is just the same as hanging clothes out to dry on a windy day—the stronger the wind, the more they shake; so with seines; if they are put into the water with it in swift motion, they are capsized or pulled out of shape; for when they are in the water and swing one hundred feet deep, they are in more than one kind of tide, for often the tide on the surface is not of the same velocity as it is deeper down. Cases have been known when the tide on the surface and the tide several fathoms down were opposite. I have often heard the fishermen say when they came in after a hard day's work, that "we have done nothing to-day; strong tide, and our seine capsized every time we placed it.'

40. All the effect we know is that the wind makes the water rough, and we cannot catch them; but I do not think the wind has much effect on them as to their habits or to drive them away, for after the hardest storms we have ever known on our coast, the fish are found where they were when the storm came on.

41. There were about ten gangs employed in Narragansett Bay for the whole season, and there were not far from one hundred men employed in working them. I leave out of this estimate those gangs that fit here in the spring, and go east and fish the whole season. My business is mostly in Maine, and in my vicinity there were fifty-five gangs, which employed over six hundred men. More than one-half of these men came from Rhode Island. Most of them fish there a short

time in the spring and fall, but the main part of their season is off the coast of Maine.

42. Most of the fish caught by the above gangs are manufactured into oil and fish guano; some are used for bait and some are used for manure just as they are taken from the water. But during the year 1873 there was but few of those caught in Narragansett Bay used for bait, because the Gloucester and Provincetown fishermen catch them with their own seines.

43. Job T. Wilson, Leonard Brightman & Son, Wm. J. Brightman & Co., Narragansett Oil and Guano Co., Thomas Dunovan, Thomas Durfee, Benjamin H. Gray, Otis Almy & Co., Chas. Cook & Co., Chas. O. Wilcox, Atlantic Oil and Guano Co. are the principal manufacturers on Narragansett Bay. The above list comprises all there are in the bay. Job T. Wilson owns three and Leonard Brightman owns two factories.

44. If my estimate is correct under question four, 160,000 barrels, at the usual estimate of 3 tons to the one hundred barrels, would give the amount of guano 4,800 tons, and the oil, at the rate of 1½ gallons of oil to the barrel, would give the product of oil for this bay at 240,000 gallons.

45. I should think the average productive capacity of our oil factories to be about six hundred barrels each; as I figure it some will manufacture one thousand barrels each day, and some will not manufacture more than two hundred barrels per day. The productive capacity for each year is immense, but the amount of fish limits it to what the figures before given will give. If all the factories had all the fish day by day that they wished, and could run from one end of the season to the other, their product would flood the world, but there are so many set-backs, such as bad weather, sharks, bluefish, that these fishermen get discouraged and go at other work. Take it all in all, there is no business on earth more uncertain than menhaden oil business.

46. Hydraulic power is mostly used in pressing oil and water from fish. Steam is used mostly in preparing the fish for the press, and also the oil is prepared by steam for market by a process not generally known. A hydraulic press costs about $12 A factory, complete, ready for business, including buildings, tanks, boilers, oil run, &c., of a capacity to take and press 800 barrels in one day, costs not far from $14,000.

47. Fish per barrel on Narragansett Bay was, during the year 1873, about 40 cents; in 1863, during the summer, $1 per barrel; and once within ten years they were $2.50 per barrel. On the coast of Maine the price paid for fish during the year 1873 was about 72 cents; the old price used to be $1, but the low price of oil and guano for the last few years has caused them to fall, and the year 1873 has been disastrous for most of the manufacturers on the coast of Maine.

48. In 1871 fish averaged on the coast of Maine 3½ gallons per barrel; in 1872 they averaged 2¾ per barrel; in 1873 they averaged about 3 gallons; the average is more uniform in Maine than on Narragansett Bay or in Long Island Sound.

49. There is no oil extracted from scrap; the oil is extracted from the fish and the water is extracted at the same time, and what is left is scrap, or, as we call it, fish-guano.

50. Fish are generally poorest in the spring when they first appear next to the shore; after cold winters they are much poorer than after warm winters, which shows that during warm winters they feed more than they do in cold winters. I have seen them so poor in this bay in the summer season that out of one hundred barrels we could not get one pint of oil; then, again, I have seen them so fat that the average would be over two and one-half gallons to the barrel.

51. The fish are fattest generally in the fall, but I have known them after a warm winter to make 2½ gallons to the barrel. But the first 18,000 barrels caught by us in Maine during the year 1873 did not make over 14,000 gallons of oil.

52. During the year 1873 the average to the barrel in Maine was one-half of a gallon more to the barrel than in Long Island Sound, and one gallon and one-half more than the average in Narragansett Bay.

53. But a few years back there was no such thing known as menhaden oil and guano business; at present there are over $2,000,000 invested, and in my opinion the business has but just begun, for apparently there are thousands of square miles of the fish, I think, and the business only wants to be known to be embraced.

54. The manufacturers sell most of their oil in New Bedford, Boston, and New York, and they sometimes export it to Liverpool and Havre.

55. The phosphate manufacturers buy most of it, and what they do not buy is used by the farmers in the pure state. It is considered to be a first-class fertilizer.

56. It is used mostly on leather.

57. Oil fluctuated from 65 cents to 32 cents during the year 1873; for the last five years I should think the average price had been 50 cents per gallon.

58. I do not think that what man does can have any effect in diminishing them, for he has increased his powers of capture for the last few years, and the menhaden have apparently increased in greater proportion than ever before. I explain the increase in this way: The menhaden, from the vast destruction by bluefish, come out at the end of the campaign far below their correct proportions, and when the bluefish ceased to trouble them they began to gain, and are gaining, and *will continue to gain* until they arrive at nature's high-water mark, and then they will stop. Buzzard's Bay, Long Island Sound, Narragansett Bay, and Cape Cod Bay used to be the home of the menhaden, but when the bluefish made those waters his home the menhaden were destroyed or driven away, probably most of them were destroyed, and now that the bluefish are about the same as gone, the menhaden begin to show themselves. This is especially true of Buzzard's and Cape Cod Bays. There have been large quantities of them in New Bedford Harbor for the last two years, and also around the Hen and Chickens.

34. *Statement of E. T. De Blois, Portsmouth, R. I., November* 26, 1877.

We have 3 steamers: E. T. De Blois, 81.30 tons, crew 13; Albert Brown, 78.05 tons, crew 13; Wm. A. Wells, 51.58 tons, crew 13; have caught 26,649 barrels of fish this season; the length of seine 300 fathoms or 1,800 feet; depth, 17 fathoms or 102 feet.

---

35. *Statement of H. D. Ball, New Shoreham, R. I., January* 11, 1875.

1. Menhaden.

6. They make their first appearance about the 1st of May in large schools.

23. They seem to color the water red.

34. Gill-nets and pounds.

41. No vessels are engaged in the business.

42. For cod bait.

43. None.

58. No.

---

36. *Statement of Henry W. Clark, keeper of Southeast Light-House, Block Island, R. I., February* 6, 1875.

1. Menhaden.

2. Menhaden are the most abundant.

3. There seem to be as many now as ever; but some seasons they are more plentiful than at others.

4. In 1873 some gangs of fishermen caught 25,000 barrels of them.

5. No; but the first are more wild, and there are more fishermen than there were ten years ago.

6. We first see them about the 1st of May. They come in abundance from the middle of May to the 1st of June. There is generally a May "run" and a June "run."

7. They swim close to the surface of the water.

8. They generally strike in on the coast of Virginia.

9. They come every season.

10. I think nets and seines scare them, and they are not so easily caught as they were before these were used.

11. They generally work in and out with the tide; but when they are making a passage tide does not affect them.

12. The rivers seem to be their favorite resorts.

13. In the summer we find them in shoal water, but in deeper water when cold weather approaches.

14. When the water is cold they swim low.

15. They leave their spawn in the rivers and shoal places.

16. We see schools of young fish about the 1st of September. The fish then are about 2 inches long.

17. They commence to leave about the middle of October, and keep leaving in schools until the middle of November.

18. They follow the coast from Maine to Cape Hatteras.

20. Their principal food is a sort of jelly-fish, I think, for where we find the most of them we find the most fish.

21. In the rivers, in June and July.

23. The spawn is generally found in large clots and appears white.

24. A warm temperature.

25. The spawn is generally found about twenty or thirty feet below the surface.

26. The eggs sink to the bottom, but do not seem to become attached to anything.

28. We see the young fish in September. They are in schools.

30. I never saw anything attached to the fish or in their mouths.

31. Most all larger fish, such as bluefish, sharks, porpoises, &c., are enemies of the menhaden.

32. They always seem healthy.

35. The nets used are about 400 yards long and 90 feet deep. They are made of cotton twine.

36. Sloop yachts are mostly employed; they are from twelve to twenty-five tons burden. There are also eight or ten steamers now in use.

37. From eight to ten.

38. The morning and afternoon are the best times.

39. Slack-water is the best time, because the tide does not tangle the net.

40. The best time to catch fish is while the wind is southeast.

41. There are about one hundred vessels employed, averaging, I think, about nine men for a crew.

42. The fish are boiled and the oil extracted; the refuse is used for manure.

43. There are several factories in Providence River.

45. It depends upon the quantity and fatness of the fish.

46. The machinery costs from ten to fifty thousand dollars.

47. From 40 to 75 cents a barrel.

48. From one to four barrels.

49. In the summer about sixty gallons.

50. One quart.

51. Five gallons.

52. Yes.

54. New York and Boston.

55. All over the country. I think, however, in New England the most is used in the Connecticut Valley for tobacco raising.

56. For tanning.

57. From thirty-five to sixty cents.

58. Yes.

37. *Statement of J. S. Crandall, Watch Hill, R. I., February* 20, 1874, *and January* 1, 1875.

1. Bony fish.

2. More numerous than any other kind.

3. Diminished.

Captain Wilcox works two fish gangs. He took in 1873 9,800,000; in 1872, 9,450,000; in 1871, 4,500,000. Another factory has three fish gangs and took in 1873 2,500,000.

5. It does.

6. About the 15th of May, and seems to come on to all parts of the coast about one time; the first are the smallest and poorest.

7. Swim high and are seen by color and ripple.

8. They come on to our coast from the southward by the east end of Long Island, and seem to work eastward and westward.

9. There are some seasons not as numerous as others; in '73 they were plentiful; in '74 not so plentiful; in fact their catch was not more than two-thirds as much as in '73.

10. It does; for last season, in the latter parts of the summer and fall, fish were taken outside of Block Island.

11. When the tide runs strong they usually go with the tide.

12. All along the New England coast.

13. No difference, as they are in all depths of water.

14. It does, as they are not as spry in cold water as in warm.

15. They do, but are all of one size.

16. Are seen in great quantities in September, October, and November, from 2 to 6 inches long.

17. November and December, gradually.

18. They work westward when leaving the coast.

20. They live on suction, and their food looks like very fine britt.

21. They spawn in July and August.

28. They are found in great quantities all along the New England coast.

29. They do.

30. The parent fish do not feed on their young.

31. Lampreys and worms are found, but are not very numerous.

32. Man seems to be their worst enemy along our coast, but they have others, as bluefish, sharks, codfish, bass, seal, porpoises, and other fish; but bluefish seem to kill them for sport, as they kill a great many more than they can eat.

33. Never knew of any.

34. Purse-seines mostly.

35. From one hundred to one hundred and fifty fathoms long and eighty to ninety feet deep.

36. Sloops and schooners mostly; some steamers are from twenty to fifty tons burden.

37. From eight to ten compose a gang.

38. All parts of the day.
39. No difference.
40. It does not.
41. About fifty; and will average from eight to ten men each.
42. They are taken to the try-works at different points along the coast.
43. Green, Wilcox, Chapman, Allen, and others.
44. Green's factory in 1873, 35,000 gals.; Captain Wilcox said he took 9,800,000 that averaged 7 gals. to the thousand. Fish have been very fat for a few past years.
46. Steam-works cost from five to fifty thousand dollars.
47. About two dollars per thousand.
50. When they first come on to the coast in the spring they yield the least oil.
51. In the fall when they are about to leave the coast they yield the greatest quantity of oil.
53. About the same as right whale oil.
54. Boston, New York, and Philadelphia.
55. All through the New England and Middle States it is used for fertilizing.
56. For tanneries and adulterating paint-oils.
57. From thirty-eight to forty cents; previous years it has sold as high as sixty-two cents.
58. It does.

---

38. *Statement of William H. Potter, Mystic River, Conn., January* 27, 1874.

1. Bony-fish.
2. More plentiful.
3. Increased.
4. Quinnipiac Oil Company, 2,174 barrels; J. Green & Co., 2,111 barrels; G. S. Allyn & Co., 1,377 barrels; Quiambog Oil Company, 355. barrels; Gardiner Oil Company, 289 barrels; R. Chapman, 200 barrels; total, 6,506 barrels @ $12.60. In 1872 there were 4,532 barrels.
5. No.
6. April and May. Not generally. Yes.
7. High. Yes. Yes.
8. From the south. Pass out east and west.
9. Not more than two weeks' difference. They fail in port.
10. Probably not, as they have increased in numbers yearly.
11. They come at the turn of the tide.
12. Long Island and Fisher's Island Sounds, Block Island Bay, and Providence River.
13. From three to twenty fathoms.
14. Yes.
15. Yes, but not always.
16. Yes. Three inches in the fall.

17. October 15 to November 15. By degrees.
18. Southerly.
19. South of Hatteras.
20. Vegetable sea-weed and a sort of white jelly which determine their distance from the surface. They follow it.
21. Here in the spring and south in the winter. They spawn in and near rivers.
22. They mix promiscuously.
24. Before and after the warmest weather; in June, July, and October.
25. At the bottom in river-grass.
26. Float near the bottom.
27. Soon after laid.
28. Yes, in shoals, generally by themselves. Near the shore in the fall.
29. Yes.
30. All larger fish. No.
31. No.
32. Greatly.
33. No.
34. Purse-nets, pounds, and seines.
35. Average, 100 feet deep, 800 to 2,000 feet long.
36. Boats of from 40 to 75 tons burden.
37. Nine.
38. All day and into the night.
39. No great difference.
40. Sometimes.
41. Sixty boats, in all employing 240 men.
42. Used for their oil; the refuse is used for guano. They are also used for bait. The oil is made at the factories along the coast.
43. See No. 4.
45. Probably twice or thrice the actual catch (see No. 4).
46. Hydraulic presses, tanks, boilers, steam or hand power and running-gear. Costly.
48. One barrel.
49. Forty gallons.
50. A quart to the barrel.
51. Four gallons. In the autumn.
52. Yes.
53. Commenced here on a small scale thirty-five years ago; it is constantly increasing.
54. New York and Boston.
55. South.
56. Painting and to adulterate other oils.
57. Forty cents per gallon at wholesale. Two years ago it was over 50 cents per gallon.
58. No.

39. *Statement of John Washington, Mystic, Conn., December* 30, 1874.

1. Bony-fish.
2. The most numerous.
3. Not changed.
5. Not late years.
6. The stragglers arrive here about the fore part of April, the schools the last of the month, and continue coming in the first half of the summer.
7. When traveling they swim low; when feeding at the surface they show a ripple. They do not attract birds.
8. They come from the south along the coast; we hear of their passing the Jersey coast eight or ten days sooner than they pass Montauk. After passing in past the outer islands, the large schools separate into smaller ones, and the farther they go from the sea the smaller they get until they arrive at the rivers and coves.
9. Their arrival each year varies but a few days. Never fail. Some seasons not as plenty as others.
10. The large schools do not come as near as formerly.
11. They travel with tides.
12. The entrance of rivers and bays when not disturbed.
13. Any depth suits them, but they swim near the surface.
14. They remain in the warm waters of the rivers and coves through the heat of summer. We also find some stragglers here in the river as late as freezing weather in the fall.
15. We find all ages, from one year up, in the large schools.
16. The young fish of $\frac{3}{4}$ to $1\frac{1}{2}$ inches long are found here passing out of all the rivers and coves which have brackish water in them. In the months of October and November.
17. Old and young begin to go in October, and by the last of November are all gone.
18. They go to southwest along the coast, and faster than they come in the spring.
19. They pass to the south of Cape Hatteras and remain through the winter on the coast and in the sounds and bays of North and South Carolina. This is the winter resort of most kinds of the summer fish of this coast.
20. When in the rivers they feed on fine moss that grows on the weeds, and a scum that floats on the surface. At sea and in the open waters their principal feed are minute jellies and brit, a minute crab that at times is so numerous as to color the water.
21. In the brackish water of all the rivers and coves into which brooks empty their waters. In the months of May, June, and July.
22. My impression is that when the fish start in the spring to migrate north along the coast, those with the ripe spawn (which are earlier with some than others, for we find full-grown spawn all the season) leave the

main school and go to the nearest suitable water and deposit their spawn, anywhere from Carolina to Maine. The fish that come in this river to spawn come in May as stragglers when the schools are outside; at that time the spawn will run and the fish are soon spent; at this time they are worthless for bait or oil, and do not get in good condition until they pass out.

23. No.

24. Forty degrees to sixty degrees.

25. On flats that are nearly dry at low water.

30. Eels and frost-fish gathered in the vicinity of the spawning-grounds.

31. Very free from them.

32. To a great extent, as all other fish feed on them.

33. Have never seen any symptoms of any.

I cannot answer the others as to catch, profits, &c., as I am not engaged in extracting oil from them.

---

40. *Statement of Leander Wilcox, Mystic Bridge, Conn., January* 15, 1875.

1. Bony fish.

2. Most plentiful.

3. Probably increased.

4. One hundred and nine thousand six hundred barrels. Mint Head Company or Noyes Neck Oil Company, 4,200 barrels; G. S. Allyn & Co., 38,000 barrels; Quinippiac Company, 36,000 barrels; R. Chapman, 9,000 barrels; Quiambog Company, 7,200 barrels; Gardner & Co., 11,200 barrels; Andrews Island Company, 8,000 barrels.

6. May 1. No. At four different times.

7. High. They make a ripple. Yes.

8. South. They pass both east and west in this region.

9. Quite regular. They never fail for more than one season; even then only partially; they return in greater abundance.

11. More are apt to come to the top at the turn of the tide.

12. Differ at different times.

13. From 10 to 100 feet, and they sometimes lie on the bottom.

14. Yes.

15. No. No.

16. Yes, in midsummer. They are from 2 to 3 inches long.

17. In December, or before, in a body or in schools.

18. As they came.

19. In warm climates, always keeping in water of a uniform temperature.

20. A fine white jelly.

21. Here in the spring and south in the winter.

22. There are a dozen or more females to one male.

23. No.

24. The water must be measurably cold, never warm.

25. Shoal.

26. Float.

28. Yes; everywhere; but they do not mix with adults; they school by themselves and are often mistaken for large fish.

29. No.

30. Eels, toad-fish, and other inshore fish.

31. No.

32. Largely from sharks, bluefish, and porpoises.

33. No.

34. Purse-seines, pounds, and gill-nets.

35. From 500 to 1,000 yards long and from 80 to 150 feet deep.

36. Small lighters, from 2 to 75 tons burden, and steamers of the latter size.

37. Ten men.

38. All hours.

39. No. See 11.

40. Not much effect.

41. About 55 altogether. They employ, say, 500 hands, beside 250 landsmen to handle and manufacture into oil.

42. Brought to their factories.

43. Quiambog Oil Company, Mint Head or Noyes Neck Oil Company, G. S. Allyn & Co., R. Chapman & Co., and Quinippiac Company.

44. On an average, one gallon to each barrel of fish. See No. 4.

45. Twice the actual manufacture.

46. Cost from $5,000 to $75,000.

47. In 1874 about 35 cents.

48. Differs very much; from 2,500 to 3,000.

53. Commenced twenty years ago.

54. New York and Boston.

55. North and south.

56. To adulterate other oils and for painting and tanning; it takes the place of whale-oil.

57. In 1874, 40 cents.

58. No. See No. 3.

---

41. *Statement of Samuel C. Beebe, Cornfield Point Light-Vessel, No.* 12, *Saybrook, Conn., January* 6, 1875.

1. Bony fish.

2. More abundant.

3. Increased.

4. Fish are measured by the thousand in cars. Luce Brothers took in 1873, with three seines, 9,000,000. In 1872, with four seines, 13,000,000. In 1871, 17,000,000.

5. It does not seem to.

6. In April; but these are not the largest. There are two runs, called the spring and eastern run.

7. High. They make ripples on the water.

8. By Watch Hill and Montauk. They work towards the bays and rivers, along the sound and at its head.

9. They have never altogether failed, but are more plentiful at some seasons than at others.

10. No.

11. In bays, &c., they move in at the flow and out at the ebb.

12. Bays.

16. They are, from June to November, at different times. Very small.

17. About the middle of November, in a body.

18. Montauk Point.

19. Southern bays and rivers.

20. Suction of scum, it is supposed.

21. In bays and rivers. During May, June, July, and August.

22. They are mixed indiscriminately.

23. No.

28. They are, in bays, rivers, and creeks.

29. No.

31. No.

32. Very much.

33. No.

34. Mostly purse-nets.

35. From 100 to 150 fathoms long, and 11 to 18 deep.

36. Sloops, mostly averaging 20 tons.

37. From 8 to 12.

38. The greater part.

39. I have never noticed any difference.

40. Not much, but they generally work to windward.

41. About 150 vessels; an average of 10 men each.

42. They are used for the oil.

43. Luce Brothers.

47. In 1873, from \$2 to \$2.50 per thousand. In previous years from \$1.25 to \$2.

48. Eight gallons to the thousand.

50. It is least in summer, and most in the fall.

56. Used for painting.

58. No.

---

42. *Statement of R. E. Ingham, Saybrook Light-House, Saybrook, Conn., March* 17, 1874.

1. Whitefish and bony-fish.

2. More abundant.

3. No.

5. No.

6. First seen in May. Main body arrives in June. First are scattering, and generally largest. There are more runs than one; intervals not regular.

7. Schools swim high, and are always seen. They attract fish-hawks.

9. Their appearance is regular and certain.

10. No.

11. They seem to have no regard to state of tide.

12. In this neighborhood the whole of Long Island Sound and the mouth of Connecticut River, for several miles up.

13. From three inches upward, indefinitely.

14. They are never seen here when the water is cold.

16. Yes, in August. Three to five inches long.

17. In October, mostly in a body.

20. Doubtful; said to be infusoria.

23. No.

28. Yes; in the creeks and coves about the mouth of Connecticut River.

29. No.

30. Enemies not known. Parent fish do not devour them.

31. No.

32. A great extent.

33. No.

34. Purse-nets and pound-nets (pens) and hauling-seines.

35. Purse-nets 100 fathoms and upward long, and 6 to 10 fathoms deep. Pound-nets 100 rods (more or less) long, and as deep as the water where they are used. Seines 60 rods.

36. With purse-nets. Sloops of from 12 to 20 tons. Pound-nets and seines, boats of 2 to 3 tons.

37. Purse-nets and seines, 8 to 10; pound-nets, 3.

38. Any part, as occasion requires.

39. No.

40. No.

41. Between Connecticut River and New Haven, probably 25 vessels and 200 men.

42. Sold for manure, or manufactured into oil and scrap (fish guano). Those for manure are used on the spot; those to be manufactured are sold to neighboring factories.

43. One at Salt Island, Westbrook, owned by John Stokes and others.

47. One dollar and twenty-five cents to $2 per 1,000 fish; not sold by barrel.

48. One and one-half to 8 gallons to every 1,000 fish, according to size and condition of fish.

54. New York City.

55. Everywhere. It is like wheat flour or greenbacks.

56. Tanning leather and adulterating more expensive oils.

58. No.

43. *Statement of J. L. Stokes, Westbrook, Conn., February 25, 1875.*

1. Whitefish.
2. Most numerous.
4. Salt Island Oil Company, 6,400 barrels
6. About the middle of May.
7. Swim low at first.
8. Around Montauk Point.
9. Quite regular and certain, though more plenty some years than others.
11. Come in on the flood tide and go out on ebb tide.
12. Bays and rivers.
13. About 15 feet. Swim all depths.
15. Mature in one year.
16. Young fish are seen in October, about 6 inches long.
17. Leave in November in continuous schools.
18. Around Montauk, bound south.
19. In a southern climate.
20. Live on suction; we always find mud inside.
21. In large bays and sounds.
28. Yes; they are some seasons abundant.
30. Eels; parent fish cannot swallow them.
31. A living species is sometimes found on poor fish, near the gills, and are called by fishermen lousy.
32. Bluefish destroy more than all other fish. Sharks and porpoises scatter and break the schools.
35. From 15 to 75 feet deep and from 40 to 100 rods long.
36. Sloop, steamers, and lighters.
37. Twelve men to a gang.
38. All times of the day.
40. They drift to the leeward in hard winds.
41. Five vessels; thirty men.
42. Used by farmers and on the spot for oil.
43. Salt Island Oil Company; J. L. Stokes, manager.
46. A hydraulic press costs $1,000 cash.
47. Thirty-seven cents per barrel in 1873.
48. Four gallons to 1,000 fish.
49. Nine thousand fish make one ton of scrap.
50. They yield double.
54. New York and Boston.
55. At patent manure manufactures.
56. Used by tanners and rope-makers.
57. Fifty cents per gallon.

---

44. *Statement of F. Lillingston, Stratford, Conn.*

1. Whitefish, generally.
2. One thousand to one.

3. General catch same. Growing scarce on shore previous to, but abundant in 1874.

4. About 5,000 barrels each year.

5. Not appreciably, according to old fishermen.

6. Seen near shore May 20. First largest, August.

7. High. Attract no birds.

8. From the east. During July and August, they came at the first flood, west-northwest to Stratford point; then south-southwest toward Long Island, and returned on ebb tide.

9. Come every year, but do not always strike on shore.

10. No.

11. Old fishermen say none in deep water. My experience is, they always follow the tide.

12. Near fresh water.

14. Yes. Swim high in warm weather.

15. Yes. Sometimes along shore; not usually in deep water.

16. Yes. Three to six inches long.

17. Last of October. At once.

18. South.

21. I have often seen, in a set-net holding 10,000, a roll of spawn 3 feet in circumference, lying on, but not attached to bottom of net; this was in June and July.

26. Sink. No. No.

28. Mouths of rivers.

30. Porpoises, sharks, and bluefish.

33. Many of those we caught on shore had a reddish blotched appearance; sometimes thousands found dead on shore appearing similar. Others were eaten as if by cancer.

34. Greatest catch is by purse-nets.

37. Ten each.

38. All day.

39. No.

40. Yes.

41. Thirty. Three hundred men.

42. Make oil.

43. Geo. W. Miles Company, Welche's Point Company.

44. One thousand to 2,000 barrels.

46. Steam boilers and tanks.

47. Fish sold by 1,000, @ $1.50 to $2 per 1,000.

48. Fifty to 100. Much more oily sometimes than others.

49. Twenty to 50 gallons.

52. Yes.

54. New York, Boston, and New Bedford.

55. Principal part goes south.

56. Tanning.

57. Thirty-five cents to $1.25.

58. No; not appreciably.

45. *Statement of B. Lillingston, Stratford, Conn., February* 23, 1874.

1. Whitefish, bunker, and manhaden.
2. Surpass in numbers all others.
3. Diminished very considerably.
5. Very much.
6. Generally about the 1st of May first seen.
7. Swim on surface; do not attract birds.
8. From east, going west.
9. Found here every season, but in equal abundance.
10. Undoubtedly.
11. Generally follow the tide.
14. Probably, as they are not found here in winter.
16. Immense numbers of young, 2 to 3 inches, long are found in this river (Housatonic) during the fall.
21. In August and September immense numbers strike on and follow up the river; those are invariably poor when so caught. In October the young appear in the river.
28. In and at the mouth of the Housatonic.
30. Bass and bluefish.
33. Large numbers are sometimes washed ashore along this coast in September and October.
34. Pounds, purse-nets, &c.
36. Vessels of light tonnage.
38. Whole day.
39. Flood tide.
40. Does not.
42. Caught for oil; refuse sold for fertilizers.
43. One in Milford Harbor, Miles & Co.
58. Very materially, in this locality.

---

46. *Statement of George W. Miles, Milford, Conn., January* 17, 1874.

1. Whitefish and menhaden.
2. There are no fish to be compared to them in abundance; they are innumerable.
3. Have not diminished, so far as a person can judge, but have rather increased. We count by the thousand; it takes $3\frac{1}{3}$ barrels for one thousand.
4. 1873, 12,000,000; 1872, 10,000,000; 1871, 8,000,000; 1870, 8,000,000.
5. No, it is not.
6. April and May. Main body arrives in Long Island Sound during June and July. Sometimes the first fish are the largest; have known small fish to come in as late as August. The schools or runs appear to come at intervals of from two to three weeks.
7. The fish swim both high and low, and can only be captured to any

extent when seen on the surface of the water; they can be seen for miles in every direction lying on or near the surface, and are discovered by the ripple on the water; also by birds, sea-gulls being attracted by them.

8. We first hear of them along the sea-coast of New Jersey and Long Island; they come into the sound by way of Montauk. The early fish follow along the Connecticut shores and up the rivers, but later in the season, when the waters are warm, they are found off shore in deep water. Occasionally they work in shore and up the rivers.

9. Their appearance is regular and certain; have never known them to fail.

10. No; but they are more difficult to capture.

11. Not noticeable.

12. Long Island Sound, during the summer months, appears to be one of their favorite localities.

13. Early in the season they prefer shoal water, and they swim low, but during the summer and fall they prefer deep water and swim high.

14. In warm weather they appear to be in thin schools and are scattered more on the surface.

15. Yes. The one and two year old fish are often found with the oldest.

16. The young fish are seen during the months of August and September, from 3 to 4 inches in length.

17. They begin to leave the sound about the 1st of September, and leave by degrees in large bodies. They are all gone by the 1st or 15th of October.

18. Same route as they come by.

19. South or near the Gulf stream.

20. Scum, or minute insect, on the surface.

21. Along the shores and rivers in May and June.

22. Sexes are mixed indiscriminately.

26. They sink to the bottom.

28. The young are found in great abundance all along the shores of the sound, "and more particularly in the vicinity of the oil factories," in large schools. I have seen hundreds of schools at a time, containing millions in a body. In fact, the expert fishermen sometimes mistake them for large fish, and make preparations to set their net before they find their mistake.

29. Seldom, if ever; occasionally we see fish that have spawns in them; it shows after being cooked; the very large ocean fish that never come into the sound but come in from sea and are captured east of New London at Montauk, south side of Long Island, Sandy Hook, and the Jersey coast; from these more particularly the spawn is found to run.

31. Occasionally lampreys. We sometimes notice red lice late in the fall on the large fish that come in from sea.

32. Sharks are their greatest enemy; these and porpoises prey upon them continually and destroy large numbers of them.

33. Never have seen any that have died from sickness or disease.

34. The nets are made of cotton twine, and purse up at the bottom.

35. Nets are from 120 to 140 fathoms long, and from 10 to 15 fathoms deep, according to the depth of water where they are used.

36. Fast sailing sloops and sloop-yachts, of from 20 to 25 tons burden, for the men who find and capture the fish, and sloops (lighters) of from 15 to 30 tons burden to carry the fish away. On the coast of Maine steamers are used in place of the yachts and lighters.

37. Eleven men and two boys to each net. The boys assist on the lighters.

38. All day, from daylight to dark.

39. The tide makes no difference with them.

40. Sometimes it does; usually they are moving to the windward when on the surface.

41. We have 12 sloops, and 50 men employed on them; also from 15 to 25 men employed in each factory. If the fish come in plentifully, we increase our working forces.

42. The fish are taken directly after being caught to the factory, and placed immediately in large tanks, and boiled by steam until thoroughly cooked and the flesh will separate from the bones when taken out of the water. Some are made into sardines, which are pronounced the best in the market.

43. The George W. Miles Company have the two largest factories; these are in Connecticut or New York State. One is a floating factory, and is moved to the locality where the fish are most plentiful: the Welche's Point Oil Company, with one net and three sloops; Fowler and Colburn, of Guilford, two nets and 6 sloops.

44. The largest quantity of oil we ever made at one factory in any one year was in 1871; we then made 100,000 gallons in about 50 working days. The largest quantity in the shortest time was 21,000 gallons of oil in 72 hours, or 7,000 gallons per day of 24 hours. This unusual quantity of oil was owing to the fatness of the fish. We made in 1872 60,000 gallons of oil; in 1873, 105,000 gallons at the two factories, one factory not being in operation the whole season on account of the delay caused by lawsuits brought by some malicious and designing persons for purposes of gain. A part of the season was thus lost, and the quantity of oil was less than what it should be.

45. The capacity for oil is limited by the facilities for capturing the fish; the nets and vessels engaged must be the best, and the men with large experience are required to make the business successful.

46. Boilers cost from $2,000 to $4,000; two hydraulic presses, with curbs and fixtures, cost $2,000 each; engines, pumps, shafting, pulleys, &c., range from $10,000 to $50,000.

47. In 1873 the price for fish ranged from $1 to $2.50 per thousand, according to the yield of oil.

48. We have worked fish when they would not make over one gallon

per thousand and from that all the way to 18 gallons. The average yield is from 4 to 6 gallons per thousand. Some seasons the fish are so poor we can barely pay expenses. We then are obliged to pay low prices for fish—say from $1.25 to $1.50 per thousand. The fishermen at those prices cannot make day wages unless the fish are very plenty. The consequence is, when the fish are scarce the men leave the business, and the vessels have to lay up until other men can be found. This is one great drawback to the business, and many factories have been obliged to give up the business on account of it.

49. This all depends on the quality of the fish, whether fat or poor, and will vary from 10 to 150 gallons, and in some rare cases as high as 250 gallons to one ton.

50. This all depends on the quality of the fish. Some days a net will take fish that will make 15 gallons, and perhaps the next haul the fish taken might not make 5 gallons; but these extremes are rare, except late in the fall, when the fish are moving south and come together from different localities; then we are as liable to get poor fish as fat ones.

51. In this vicinity, during July, August, and September, we get the fish only that come into the sound for their feeding-ground, and which fat after they get here. If they are poor, we have the largest catch in June and July. If they are increasing in fatness or yield of oil, we cannot capture them sucessfully until August and September. The fat fish in the sound are usually wild and hard to take until late; this may be owing somewhat to the fact that the feed is plentiful and low in the water. When we have an unusual dry season, so very dry that cress are almost a failure, then we are pretty sure of fat fish and an unusual quantity of jelly-fish floating on the water, which perhaps may be one source of supply of feed. On the other hand, in very wet seasons we find them below the average in yield of oil.

52. The northern fish always yield more than the southern. The fish appear here and farther north nine seasons out of ten "spring poor," as the farmer terms his cattle that have been exposed to the inclement weather and fed on coarse fodder; but after they get here, if their feed is plenty, they fatten very fast. This can be proved by the past season. During the months of May and June one million of fish would make only eight hundred gallons of oil; in August, the yield was from eight to ten gallons per thousand, and in September ten to twelve gallons per thousand.

54. The market for oil is principally in New York and Boston. The dealers in those cities have a very extensive trade all over this country, and large quantities are shipped to Europe.

55. The scrap is used very extensively in a raw state by the farmers and tobacco-growers of Connecticut, Rhode Island, Massachusetts, Long Island, and New York State. It is a standard manure and fertilizer when used judiciously by those who understand how to use it. The principal market is with the superphosphate manufacturers. When

manufactured it is in a much better condition for use, and can be applied more evenly to the land and in much smaller quantities to the crops without danger of burning. This is the greatest source of supply this country affords for a manure rich in ammonia, and it is worth more to this country than the islands that furnish us with Peruvian guano. In the season of 1873 there were landed in the cities of Charleston, S. C., and Savannah, Ga., alone 85,000 tons of superphosphate, nearly all of it having fish-scrap as its base.

56. The oil is used mostly by tanners and curriers; it is also used for outside painting.

57. Prices ranged in 1873 from 60 cents in April to 40 cents in August; then to 46 and 48 cents in September; then the panic burst upon the country and brought business to a stand-still. Prices for a few past years have ranged from 45 to 60 cents.

58. It is not possible nor in the power of man, with all the modern improvements at his command, to materially diminish their numbers.

On the shores of Connecticut 88,200,000 fish, producing 8,820 tons of scrap, valued at $16 per ton in bulk at the factory, were caught, and 309,900 gallons of oil were made, bringing 45 cents per gallon. On the shores of Long Island 82,700,000 fish, producing 8,270 tons scrap, at $16 per ton, were caught, and 291,200 gallons of oil were made, bringing 45 cents per gallon.

The above is a correct statement, as near as possible, of all the fish caught on the shores of Connecticut and Long Island during the season of 1872. Comparison with the previous year shows a decrease in the catch of fish of some 70,000,000, which would make, at the average yield of oil this year, 245,000 gallons, and about 7,000 tons of scrap. The decrease in the catch is readily explained: there were some six or eight manufacturers less than in 1871, some having stopped business on account of threats of lawsuits by malicious persons, who attempted to break up every honorable and profitable business.

Notwithstanding the decrease in catch of fish there were more seen in the waters, and those who persisted in catching from the beginning to the end of the season caught more than they did the previous year; in fact, fish were never more plentiful. It would seem, from the great quantity caught from year to year, that whitefish would soon be extinct; but it is a surprising fact that for the past few years they have been steadily increasing in numbers.

---

47. *Statement of W. S. Havens, Collector of Customs, Sag Harbor, N. Y., January* 1, 1875.

1. Menhaden.
2. More than all other kinds together.
3. No apparent change.
5. Not perceptibly.

6. April; come in schools; largest in the fall.
7. Generally near the surface.
8. Come and go, south.
9. Some years they are a partial failure, but I do not know the cause.
10. Yes.
11. None perceptible.
12. In this district; Gardiner's Bay.
13. Swim near the surface.
14. Yes, they leave soon after cold weather.
15. Generally find them of the same size.
17. Leave in a body.
18. For the south.
20. On a mossy substance called bunker-feed.
21. In creeks, inlets, and rivers.
22. All go together.
23. Not discovered.
24. Moderately warm.
25. Various depths.
26. Think they settle to the bottom.
28. Rarely seen at all.
29. Believe not.
30. Sharks and bluefish devour them.
31. They are not found there.
32. To a great extent.
34. Purse-nets.
35. Length, 150 fathoms; depth, 100 feet.
36. Sloops, and schooners of from 15 to 20 tons burden.
37. Nine men.
38. About three-fourths of the day.
39. No.
40. East winds break them up.
41. Sixty vessels and 540 men.
42. Used near by.
43. About 20. Wells, Parsons, Vail, Tuthill, and others.
44. Five hundred barrels to each factory.
45. From 1,000 to 1,500 barrels.
46. Steam and try-pots; from $5,000 to $10,000.
47. Say 30 cents.
48. 200 fish.
49. Some more, and some less.
50. One quart.
51. Four gallons to one barrel.
53. Say twenty years.
54. New York.
55. Southern States.
56. Painting and adulterating.

57. Fifty cents to $1.

58. No; if it does we do not notice it.

---

48. *Statement of J. Morrison Raynor, Agent for Sterling Company, Greenport, December 20, 1877.*

The number of gears and sail employed by us the past season was three, consisting of three yachts, six lighters or carry-away boats. The Swan, 24.64 tons; the Mary H. Sisson, 20.95 tons; the Dauntless, 19.70 tons; Titus, Bunker City, 8.64 tons; Rough and Ready, 10.24 tons; sloop Sarah, 10.39 tons; sloop Kate Romer, 9.83 tons; sloop Friendly, 13.37 tons; sloop John Marcy, 12.50 tons. Each gang consists of 8 men, 2 boys, 1 cook—making 9 men and 2 boys; total, 27 men and 8 boys. The men fish for a share and not for wages, except cook and boys hired by them. Use purse-seines; are about 125 to 150 fathoms long, 80 to 100 feet deep. The number of fish taken by them was 14,449,000.

---

49. *Statement of Hawkins Brothers, Jamesport, N. Y., February 25, 1875.*

1. Mossbunker or menhaden.

2. Much more numerous.

3. Cannot perceive any difference.

5. Cannot perceive that it does.

6. About the 1st of May, on the coast of Long Island. The first are usually the largest. The schools come in at intervals from the 1st of May to the last of August.

7. They swim both high and low, but usually the former, and make a ripple on the water, attracting fish-hawks only.

8. Come from the south, following the coast and stopping in the bays and sounds.

9. They are not regular but are certain, and are more plentiful in some localities and at some seasons than others.

10. From experience we think not.

11. Think they move toward the shore more on the flood than on the ebb tide.

12. In bays, sounds, and their entrances.

13. In all depths on the coast and in the bays.

14. It does.

15. Think not; we find no small fish in the spring of the year. I believe these fish get their growth in one year.

16. Yes; from July to November, from one to six inches long.

17. Commence to leave in October by degrees.

18. Following the coast south.

21. In heads of bays in the spring.

28. In great abundance in the heads of bays when first spawned, gradually dropping out into deeper water as they attain size.

29. I think not.

30. Don't know of any; think not.

31. Nothing but an insect, which the fishermen call lice, is occasionally found on the outside of fish, eating into the body.

32. To a very great extent, especially bluefish.

33. Never have known any.

34. Set-nets, pounds, haul-nets, and purse-nets.

35. Haul-nets are from ½ to 1 mile long, depth according to depth of water where the fishing is done; purse-nets are from 600 to 1,000 feet long, and from 70 to 90 feet deep.

36. For purse-nets, sloops, schooners, and steamers, of from 10 to 50 tons burden.

37. To man a purse-net, 11 men.

38. All parts.

39. Think more on the flood tide.

40. It does.

41. Number of vessels, 191; whole number of men, 715. This includes purse-nets only.

42. Sometimes they are used in the raw state for manure, but are principally carried to the factories, where they are manufactured into oil and scrap.

43. On Barren Island, Jones & Co., V. Koon, Goodkind Bros., Hawkins Bros.; on shores of Gardiner's Bay, D. Wells & Sons, Sterling Oil Company, Horton & Co., Green & Co., Jonathan Preston & Co., Cartwright & Co., Frank Price & Co.

44. About 25,000 gallons.

45. According to the fatness of the fish; say, 30,000 gallons.

46. Engines, boilers, steam-pumps, hydraulic power, and piping, from $15,000 to $25,000.

47. 1873, Barren Island, 50 cents; Gardiner's Bay, 60 cents.

48. Barren Island, ½ barrel; Gardiner's Bay, ⅓ of barrel.

49. Barren Island, 57 gallons; Gardiner's Bay, 85 gallons.

50. One gallon; in midsummer.

51. Four and one-half gallons in October and November.

52. Northern fish yield most oil.

53. The manufacture of oil was commenced on the shores of Gardiner's Bay about 1850, when the oil was extracted by fermentation.

54. New York, Boston, and New Bedford.

55. New York, Connecticut, New Jersey, Maryland, and Virginia.

56. Painting, tanning, rope-making, and soap-making.

57. Forty-five cents per gallon; previous years from 45 cents to $1 per gallon.

58. It does not.

50. *Statement of Benjamin H. Sisson, Greenport, R. I., January* 29, 1874.

1. Moss-bunkers.
2. They are most numerous.
3. No apparent difference.
4. In 1873, 50,000,000; 10,000,000 additional for shore fisheries.
5. No.
6. In March and April. On the 1st of May. The first are the largest. There are different runs coming in, and at intervals of six weeks.
7. The first run are known by their capture: all others by sight and by birds.
8. From the south.
9. The fish never fail, but some years they are scarce.
10. Yes.
11. In certain localities a flood tide is considered the most favorable for a catch.
12. Shoal-water.
13. From 10 to 12 feet.
14. Yes.
15. Yes. Sometimes they are mixed.
16. Yes. From July to November. From 1 to 6 inches long.
17. From September to January. By degrees.
18. Ocean routes.
19. I hear nothing from them south of Cape Hatteras.
20. Marine animalculæ, with small strong fiber.
21. There seems to be much difference of opinion about this among the fishermen; my own impression is that of the first that come in the spring, the old fish go stealthily into all the shoal and water bays, deposit their spawn and milt, then go out again and join the general migration east. These spawn hatch by the last of June or first of July, as the small fish are first seen in these localities about this time. No doubt there is another spawning time in the fall, outside, in deep water.
22. They are mixed indiscriminately.
23. Yes, in deep water.
24. Cool water.
25. Near the surface.
26. I think they float.
27. In June and July. From one month to six weeks.
28. Everywhere in abundance.
29. Not unless handled roughly.
30. Eels and bluefish. No.
31. Worms, crabs, and lampreys are found on the outside, but not within.
32. Very much. I have seen 100 moss-bunkers taken from one shark.
33. We have not noticed any in this district.
34. Purse-nets, gill-nets, seines, and pounds.
35. Purse-nets are from 900 to 1,000 feet long and 100 feet deep Gill-

nets are smaller; from 60 to 500 feet long, by 10 feet deep. Shore seines are from $\frac{1}{2}$ to $\frac{3}{4}$ of a mile long and from 20 to 30 feet deep.

36. Steamers, schooners, sloops, and cat-rigged boats, from 5 to 50 tons.

37. Nine.

38. All day.

39. This depends on the locality.

40. They often leave during high winds.

41. One hundred and five vessels and 400 men.

42. It is principally turned to oil and guano.

43. D. D. Wells & Sons, Sterling County; Hawkins Brothers; H. Corwin & Co.; G. P. Horton & Co.; Vail & Benjamin; Benjamin Buy Payn; Green & Co.; B. C. Cartwright; Floating fish-factory "Falcon," of 2,500 tons, Capt. George Tuthill; Floating fish-factory "Ranger," of 1,500 tons, Capt. Frank Price.

44. From 10,000 to 60,000 gallons.

45. From 1,000,000 to 2,000,000 per week.

46. Boilers and engines, costing from ten to twenty thousand dollars each.

48. Some fish will make half a gallon per thousand; some 22 gallons.

49. Eight thousand fish will make one ton of green scrap.

50. One gallon per thousand in the spring and fall.

51. Twenty-two gallons per thousand. In September and October.

52. Yes.

53. The moss-bunker business previous to 1850 had been carried on for a long time—certainly as far back as 1800. The seines used were very long, and were handled from the shore. They frequently caught 1,000,000 fish at a haul. These fish were used by farmers in a raw state for top-dressing. Some portion of them were buried, however, and used as a compost. In the year 1850, D. D. Wells & Son started the first factory in this vicinity, using steam for making oil and scrap. At the same time there were other parties using a few pots (whalers' try pots), boiling the fish in water and making a very indifferent oil and scrap; these, however, were not successful, and were soon abandoned. The first oil made by D. D. Wells & Son was of a very dark color, and contained much fleshy matter, which made it very offensive to the smell. It did not come into much use for some time, and for a long time the profits were small; but by persistent effort on their part, in perfecting machinery, the quality of the oil was so much improved as to come into general use for certain purposes: for painting, tanning, in the manufacture of rope, and for the adulteration of other oils; the scrap was also very much improved by drying, grinding, pulverizing, &c.; thus the business continued so prosperously that during the war the business had come to be quite remunerative. At that time, under the impulse of high prices and plenty of money, quite a number of factories were put up, and for two or three years the business was some-

what overdone. Since that time many have gone out of the business altogether; others have consolidated, and at the present writing there are ten establishments in operation and are doing a fair business, giving employment to a large number of people and bringing up a hardy race of boatmen and sailors. There is about $500,000 invested in the business in this vicinity.

54. New York, Boston, and Europe.

55. The Connecticut Valley and the Southern States.

56. For painting, tanning, manufacture of rope, lubricating, and adulteration.

57. Thirty-two to 47 cents per gallon in 1873; 40 to 50 cents per gallon in previous years.

58. The general opinion is that there is no diminution.

---

51. *Statement of David G. Vail, River Head, Long Island, March* 20, 1875.

1. Menhaden.

2. More abundant than any other.

3. Has not diminished.

4. Fifty millions of fish in 1873, and as many in 1874; in this vicinity we measure them and pay for them by the thousand, calling each fish 21 inches, or taking up that amount of space. When they are fat they are larger, and then by measure we would get perhaps only 800 fish for 1,000; then sometimes they come small, and poor, and we would get, perhaps, 1,200 fish for the 1,000. In Maine they measure them in barrells, calling 300 fish to each barrel.

5. Not any, judging from my experience for the last ten years.

6. From the 1st to the 10th of May.

7. They swim low when they first come, if the weather is cool, but soon come to the top of the water, and are known as top-water fish.

8. They come from the south, following the coast generally.

9. Their appearance is regular and certain; I never knew them to fail; but they are sometimes more plentiful on some grounds than on others.

10. I think it does tend to change their ground.

11. Generally they go with the tide.

12. Bays and sounds.

13. We find them in any depth of water, but generally they swim on the top of the water.

14. They like warm temperature.

15. We find one and two year old fish all mixed together.

16. Yes; they are spawned at the head of the bays, and stay all summer, until they are half grown.

17. They leave about the 1st of November, generally in a body.

18. By the same route as they came, following the coast south.

19. Somewhere south.

20. Kind of very fine jelly fish; they suck their food, for they have no teeth.

21. At the head of bays generally, at all times of the season.

22. I think they are indiscriminately mixed as to male and female.

23. No.

24. Warm temperature.

25. Near the bottom.

26. They float in the water until hatched.

28. Are in abundance in the locality where they are hatched.

29. Yes, when nearly matured.

30. All kinds of fish destroy them, except the parent.

31. No.

32. They do not suffer any when compared with the quantities of them.

33. No.

34. Purse-nets.

35. From 600 to 1,200 feet long, and 80 feet deep.

36. Steamers, sloops, and schooners, from 10 to 100 tons each.

37. About 12 men to each net, with 3 boats or sloops.

38. All day, unless they load their boats sooner.

39. No.

40. Do not think it does.

41. Fifty vessels, and 175 men.

42. They are sent directly to the factories by the boats that follow the net for that purpose. They are sometimes used as food, and are very sweet, but bony.

43. There are 10, owned by George F. Tuthill & Co., F. Price & Co., D. Wells & Son., J. Preston & Co., Vail, Benjamin & Co., Hawkins Bros., H. P. Green, B. C. Cartwright & Co., G. H. Payne, and Fithian & Horton.

44. Six hundred barrels of 40 gallons each.

45. They could manufacture large quantities if they could get the fish and have them fat.

46. Boiler and engine, hydraulic presses, large tanks for cooking and packing cost from $10,000 to $50,000.

47. From $1 to $2 per barrel; say $1.50 for the season.

48. Two hundred fish are about an average for the season.

49. Depends on fatness of fish; it takes from 8,000 to 10,000 fish to make 1 ton of scrap.

50. Sometimes when very poor we cannot get over ½ gallon of oil, that is in the spring and summer.

51. When very fat 6 gallons can be taken from 1 barrel.

52. Yes.

53. The manufacture of oil from menhaden was started in this vicinity about thirty years ago by Daniel D. Wells, who boiled them in large

kettles and skimmed the oil from the kettle; then there was only about one-half of the oil saved. Since then the business has increased until now an enormous business is carried on.

54. New York.

55. Phosphated for the Southern States.

56. Used as a lubricating oil and by leather manufacturers; also for paint.

57. Price in 1873 was about 45 cents a gallon; from 75 cents to $1.10 in previous years.

58. No; not by any mode that has been practiced.

---

52. *Statement of Joseph Whaley, Point Judith Light, Point Judith, R. I., December* 28, 1874.

Mr. BAIRD:

SIR: I have received a circular in regard to the fish known in this vicinity as menhaden. I will answer all questions I can. I did not receive any blank, so I put it on this.

1. Menhaden.

2. More plentiful than any other kind.

3. I think I saw more pass here last June than any time since 1862.

4. Five hundred barrels.

5. I do not think that it does, as they are as plenty now as ten years ago.

6. The first fish are seen about the 20th of May; the main body get along about the middle of June. They pass here to the east from the 20th of May to the 1st of July.

7. They, as a general thing, near the top of the water, and make a ripple or a slick. They do not attract birds, as they do not drive up any small bait or other fish.

8. From the south and bound north and east.

9. Very regular sometimes; if the weather is cold and easterly winds prevail it puts them back ten to fifteen days.

10. I do not think it does.

11. They go or move with the tide, or the way the tide is setting.

12. Rivers and bays.

13. Sometimes high, and sometimes about half way to the bottom. I think they prefer water from 10 to 20 feet deep.

14. They leave here when the water gets too cold.

15. I do not think they do. I cannot tell the young from the old, as they get their growth in a year. I have seen them shut up for nine months; they have then nearly their length.

16. They are seen in large quantities in November; they are about 2 inches long.

17. They begin to leave in October, and continue to the 15th of December by degrees.

18. Southwest.

19. Some place where the water is warmer than it is here.

21. In rivers and bays.

28. They are, in river and bay, and all along shore.

29. Yes; they suffer most from bluefish and striped bass when they are young. I do not know to what extent.

34. Purse-seines and gill-nets.

35. The length varies from 200 to 300 yards; the depth from 20 to 60 feet.

36. Sail and steamers.

58. I do not think that it does.

I will here state that there is a great many fish taken near this point, but as there is no harbor near they are carried away to market. This is a passing point for most all kinds of fish to pass from the south to the north, from the east to the west.

---

53. *Statement of A. G. Wolf, Absecom Light, Atlantic City, N. J., March 6, 1874.*

1. Mossbunker.

2. More numerous than any other fish.

3. No difference.

4. Two hundred and fifteen barrels by Adams & Co. About same last year.

5. No.

6. In April; main body in July. No. Yes. Depending on tide.

7. Very high; fins out of water; come in a solid body, as deep as you can see in the water. They make a ripple and can be seen on calm days for half a mile. Attract birds, such as fish-hawks and sea-gulls.

8. Come from the south; shift into and out of inlets with the tide.

9. Have never failed to come in regularly.

10. Has no effect.

11. Drift with the tide.

12. No favorite feeding grounds.

13. Swim high, and are seen in both shoal and deep water.

14. No.

15. Come in all sizes; cannot tell their age.

16. In the fall you can see millions of little fish not over two inches long.

17. Leave by degrees, beginning in September.

18 Go south.

19. South.

20. Can't tell; they take no bait.

21. Up in the bays and inlets in spring.

24. Seem to prefer warm water, for they go up the bays as far as possible.

26. Settle and become attached to shells and stones.
28. Yes; in fresh-water creeks.
29. Yes.
30. Bluefish catch the fish. Parents do not eat the spawn.
31. Bug or fish-louse on outside; a worm is attached to the outside and bores into them, and sometimes a bug is found in the roof of the mouth.
32. Suffer from all fish; bluefish are their worst enemy.
33. Not here.
34. Gill and purse nets.
35. One hundred to three hundred fathoms long, 12 feet deep.
36. Boats from four to five tons for gill-nets; schooners, sloops, and one steamer of from ten to twenty tons for purse-nets.
37. Eleven men to a net.
38. All day, if good weather.
39. No.
40. East wind affects them.
41. Ten vessels; forty men.
42. Tried out near Little and Great Egg Harbors.
43. None in the neighborhood.
44. Two hundred and fifteen barrels.
45. Not known.
46. Five thousand dollars in one factory.
47. One dollar and twenty-five cents per thousand fish.
48. Four gallons of oil per thousand fish.
49. Forty gallons.
50. Least in August.
51. Greatest in November, eleven gallons per thousand.
52. Northern fish yield most.
54. New York City.
55. The South.
56. For tanning and adulterating paint-oils.
57. Forty-five cents per gallon.
58. Does not seem to diminish them.

Questions were answered by Messrs. Bowen, Strickland, and Conover, of Atlantic City, and Capt. John D. Sanders, of Leedsville, N. J.

---

54. *Statement of Albert Morris, Somers Point, N. J., January* 12, 1875.

1. Mossbunker.
2. There are a thousand times as many.
3. No.
4. 7,200; 1874, 12,000.
5. Think not.
6. About 1st of May. The main body arrive about 20th June. There are sometimes three or four runs a week.

7. High, so that they can be seen.
8. Mostly follow the coast.
9. It always has been regular.
10. It does not, for sometimes they are caught in 2 feet of water.
11. Go with the tide.
12. From the beach to about five or six miles from shore, and sometimes more.
13. From 1 to 10 fathoms.
14. It does.
15. They do both.
16. They are in great abundance, and are from 3 to 5 inches in length.
17. About the middle of September, but the eastern run comes along about the last of October.
18. They follow the coast.
19. From Chesapeake Bay to Cape Hatteras.
20. A very small substance, scarcely seen by the naked eye when the sun shines.
21. Along the coast.
28. They are, along the coast.
29. They are.
31. Crabs are found in the gills.
32. To quite an extent.
33. Yes; in October, 1873, they floated ashore by tons.
34. Purse-nets.
35. Two hundred fathoms long, 500 meshes deep.
36. Sloops of about 20 tons.
37. Seven.
38. All day.
39. Most of our fishing is done out at sea, where the tide does not make any difference.
40. It does, especially easterly winds.
41. Three vessels; 9 men.
42. For manure (guano); part is used in the vicinity, and part shipped to Wilmington and Philadelphia.
43. Somers Point Oil Works, John D. Sanders, J. S. Adams, and others.
44. About 300 barrels.
45. Two thousand barrels.
46. Pot work. Costs $8,000.
47. Thirty-one cents per barrel.
48. One barrel.
49. Forty-five gallons.
50. One quart; in the summer, July and August.
51. Four gallons, in October and November.
52. They do.
54. New York.

55. Wilmington.
56. Painting.
57. Forty to 50 cents per gallon.
58. I think not.

---

55. *Statement of D. E. Foster, Cape May Light-House, N. J., February* 15, 1875.

1. Bony fish.
2. They are more numerous than any other fish visiting our coast.
6. They come from the south; the first arrival is about April; these fish are larger but not so fat as those which come about July.
7. They generally swim in schools near the surface.
17. They leave about November, heading to the north.
30. They are preyed upon by sharks, porpoises, fish-hawks, &c.
33. I have not known of any disease to prevail among the fish here.
42. They are used mostly for manure. There is no oil manufactured here.

---

56. *Statement of A. A. Owens, Philadelphia, Pa., March* 31, 1875.

1. Oldwives and mossbunkers.
3. Cannot perceive either way.
4. None.
5. No; there are very few captured.
6. They are first seen in June and July. The last are the largest.
7. They swim high and make a ripple.
8. From the northeast in large schools.
9. They seldom fail.
10. I think not.
11. They come in on the flood and pass out on the ebb tide.
12. Along the coast and in the inlets.
13. They generally prefer deep water.
14. They become somewhat torpid when sudden cold weather comes.
15. Sometimes both together.
16. There are no very small ones seen.
17. They leave by degrees in the fall.
18. Northward and eastward.
22. They seem to mix indiscriminately in schools.
29. I think not.
30. The bluefish is their greatest enemy.
32. They are destroyed in great numbers by fish on the coast.
33. Very seldom in this vicinity.
34. Pocket nets and seines.
43. None.
51. Greatest in the fall.
54. New York and Philadelphia.

55. New York and Philadelphia.
57. Fifty cents per gallon.
58. We cannot see that it does diminish them.

---

57. *Statement of James H. Bell, Mispillion River, Delaware Bay, January 23, 1875.*

1. Oldwife, a corruption of alewife, is the name universally applied to the fish in this vicinity, and all along the western shore of Delaware Bay.

2. They rank equal to if not more abundant than the sea trout, and far exceed the number of any other fish; a thousand bushels of trout are sometimes taken at a haul; but the main fishing season does not last over a month, while menhaden are caught more or less during six months of the year.

3. No diminution is noticeable; the number seems to be about the same one year with another.

4. These fish are not sought in this vicinity for any purpose whatever; and when caught in seines laid for other fish by fishermen, are left on the beach to rot, or taken home and fed directly to hogs, or composted for fertilizing the soil, for which they are only valuable.

5. Quantity taken from the water never seems to affect the supply.

6. They are first seen here early in March, and continue to increase in number till about the 15th April, when the sea-trout frightens them off. They soon return in increasing numbers, however, till the middle or last of May, after which they begin to disappear in large schools until about the 1st August, when they again appear numerous, and continue so, if the weather is mild, until the latter part of September, when they begin to disappear.

7. High; by their capture at first, windy weather generally prevailing in March, renders the bay too rough for the ripple to be seen; besides, they are not inclined to show themselves about the surface till the water becomes warm, as in August and September; the fish-hawk and trout-gull follow closely in their wake, and destroy a great many.

8. The opinion prevails, that after entering the bay they follow the main channel, spreading toward the shore on either side as they advance, until arrested by brackish water. The western shore of this bay is very shallow, the tide near the beach seldom rising above six or seven feet. When the tide is three-quarters flood, the fish run in close to land, and are caught within twenty yards of the beach; as none are seen on the surface at such times, it is probable that they are then in pursuit of food; at slack-water to first quarter ebb, if it is calm, the water is spotted with the break or ripple; and as the tide recedes they float out with it to deep water.

9. Their appearance is as regular as the shad; an old fisherman remarked to me that he never knew it to fail, or a diminution in their

abundance for a single season; hence, no cause is assignable for a decrease when none is known.

10. No gill or haul seines frighten them if they are out of sight; but when sunning on the surface, any noise close by sends the school out of sight in an instant, to reappear not far off; if the object was to catch them, this is the most favorable time, and the purse-net is most likely to accomplish it.

11. In-shore on the young flood to feed, and out to deep water again when the ebb is not lower than four feet.

12. Sandy bottom predominates on this coast, and there is where most fish are found, although they are caught in numbers where the bottom is muddy. Some few fish are found considerable distances up the creeks at high water.

13. Most fish are found in 10 to 15 feet of water, or deeper; they are also caught in large numbers in water as shallow as 6 feet; sometimes when it is not deeper than 4 feet.

14. Not known, but am inclined to think they prefer warm water until arriving at full size.

15. Medium and small fish are found together, not probably in the same schools, but close enough together for the seine to catch fish ranging in size from 9 inches down to 3 inches.

16. Yes; immense quantities of them from about the 10th September to 1st October, in size from 3 inches up, and smaller ones, probably, but I have not seen any.

17. Toward the latter part of September they gradually disappear.

18. Run out to the main bay-channel; beyond that I have no knowledge.

19. It is impossible for me to say with certainty, but I think near the Gulf Stream in the Atlantic Ocean, from the fact that this fish appears so partial to warm water.

20. I have not the least doubt that their food is something similar to that of shad, such as minute animalcula found in muddy bottoms; their digestion is evidently very rapid, as the contents of the stomach bear a nearer resemblance to black mud than to anything else.

21. But for what took place about the 7th of last November on this coast I should hesitate to give any opinion in reply to this query. After the last menhaden had disappeared from these waters, and as late as the 7th November, all at once from Cape May to Cape Henlopen, and up the bay 18 miles, to and above this station, the water was crowded with the largest size of this fish ever seen by any person on the coast, the largest being quite as big as medium-sized shad, extremely fat, and full three-fourths of them pregnant with large and nearly matured roe; the shores of the bay from Lewes up this far were lined with dead fish, bitten to death by bluefish. Some of the latter weighed 25 pounds. Numbers of dead fish were without tails, and all were more or less mutilated by the teeth of the bluefish, or snapping mackerel as it is called at Cape May.

Whether they were exterminated by their enemy or driven back to the ocean is not known, but not one of them could be caught on the coast sixty hours after their arrival, and none have been seen since; nor were they ever known here before so late in the season, or of such large size, or containing the fully-developed roe, or, in fact, any roe at all. Such fish are entirely new to these waters. I am of the opinion that the ocean is their spawning element, and being attacked while spawning by immense numbers of very large bluefish, they flee before it till reaching shallow water, then, if all were not killed, turn and escape to sea. These fish were remarkable for uniformity in size, being over a foot long and about one inch and a quarter thick through the back. A gentleman remarked to me that he thought none of us had ever seen any full-grown "oldwives" before. Ordinarily this fish is not marketable, but so anxious were the people after these large ones that $14 per barrel was offered for them salt. It seems to me that if spawning was the object of these fish they would have remained longer than two days and a half, and that some would have been caught in former years. From a critical examination and comparison of these with those common to the coast I can find no difference except in size. Finally, as the spawn of these fish appeared matured, I am of the opinion that they spawn in the ocean, and in the month of November. (Since the visit of bluefish, rock and perch, usually quite plenty, have entirely disappeared.)

22. Sexes are mixed.

23. No.

28. Yes, in thousands, near the shore from Cape Henlopen to above this river. It is a peculiarity of the young fish in a strong current to spring from the water, causing persons unacquainted with the habit to remark that "the water is alive with fish." So it is to a certain extent, but it is difficult at such times to find any other kind of fish in it.

29. I saw a great many of the large fish handled, but in no instance did I see the spawn escape, nor do I think it ever occurs with this fish.

30. I have no knowledge of the destruction of spawn, and do not believe the parent fish capable of devouring either spawn or young fish, but instead obtain their food from the mud. The worst enemy of young fish, by all odds, is the sea-trout. From one to three may be found in the stomach of almost every trout, and as trout remain here, more or less plentiful, till September, an immense number of young fish are destroyed. Bluefish is the next most destructive enemy. Other kinds of fish trouble them very little compared with the two above named.

31. I have never examined the roof of the mouth, but have frequently noticed a little bug-like crab attached to the gills of medium sized fish. During August and September it is common to see a slender red worm or leech fast to the fishes' sides. The worm is largest at each end, is about one inch and a half long, and bears some resemblance to the angle-worm. As many as a dozen are found on some of the fish. Al-

though the worm seems as frail as a strand of blood, it is strong enough not to break when its head is pulled away from the fish.

32. The larger fish appear to suffer most from bluefish, although porpoise, shark, and the fish-hawk destroy a great many.

33. None that I am aware of.

34. Mostly in haul-seines, many in gill-seines, but in neither seine is menhaden the object.

35. Seines are from 15 to 100 fathoms long, from 6 to 9 feet deep, and have 1-inch meshes.

36. None. Four-oared boats are generally employed to lay out and draw the seine ashore.

37. From eight to ten men are necessary to manage a boat and large seine.

38. Flood and high tide; sometimes on the ebb, but never at low water.

39. Flood and high water are the most favorable times.

40. The fish usually works against the wind if there is much of it.

42. Some leave the fish on shore, others feed them to hogs, or compost them to enrich their land.

58. I am confident, from observation, that catching large numbers of any kind of fish in the spawning season will diminish them, but owing to this fish not spawning on this coast, I regard it next to impossible to decrease their numbers by any method of capture known to fishermen.

---

58. *Statement of Benjamin Tice, Maurice River Light, January* 11, 1875.

1. Known by the name of mossbunker or aldwives.
2. They are more abundant than any other kind.
3. Increased in numbers, I believe.
5. No establishment in this vicinity.
6. They come on early in the spring, and are thickest in August.
7. They swim high and make a ripple on the water.
16. Young fish are seen in the months of August and September.
17. Leave the coast late in the fall and by degrees.
31. I have seen worms attached to the outside.
32. They suffer from the attacks of sharks, porpoises, &c.

---

59. *Statement of Joseph B. Benson, Bombay Hook, Del., January* 18, 1875.

1. Mossbunker, old-wives, bug-fish, and green tails.
2. They are more plentiful than any other fish during July and August.
3. It has not.
4. There is no establishment on the west side of the bay.
5. It does not.

6. The last of April, July, and August they are about the same size. There are no certain intervals in the schools.

7. At times the surface of the water is covered for long distances, and at other times they swim deep. They attract fishing-hawks, which live on them.

8. They come on in the spring and leave in the fall.

9. They are certain to come, but if the season is very wet they are later.

10. It does not.

11. It does not make any difference.

12. Near shore.

14. They like it warm.

15. They are all alike.

16. In August and September there are large schools of them.

17. In October, by degrees.

18. By the capes.

20. It is not known.

21. Where the water is brackish.

28. Some seasons they are abundant near the shore and at other seasons there are none.

30. Rock. Taylor fish.

31. There is a bug found in the roof of the mouth.

32. They suffer to a very great extent.

33. I have not noticed any.

34. Gill-seines.

35. One hundred to 150 fathoms.

36. They are only caught for bait.

38. Whenever convenient.

39. No.

40. No.

41. There are none.

42. They are often taken for manure.

43. There are none.

44. There is none made.

58. It does not.

---

60. *Statement of Hance Lawson, Crisfield, Md., January* 22, 1874.

Not a report with reference to Atlantic coast.

1. Alewife.

2. Most abundant.

3. Diminished.

4. At Manokin factory 800 barrels of oil were made last year. At Tangier Island about the same or less.

5. Yes.

6. They are first seen about May 1.

7. They swim both high and low; when high, with their heads out.

8. They come from the south, moving along slowly with the tides; up in the spring and down in the fall.

9. There is sometimes a scarcity, but never a failure.

10. They do scare them badly.

11. They come into creeks with the flood and go out with the ebb; sometimes, however, they come in at night.

12. Generally deep water; however, they sometimes work in-shore on the flood tide.

13. A depth of 10 or 12 feet is preferred. They swim on the top of the water.

14. Cold weather makes them torpid.

15. Seldom, and the sizes go in separate schools.

16. They are never seen on the coast, but are in the sounds, rivers, creeks, and bays.

17. They begin to leave during the latter part of August, and the first to leave are the best; some remain until the middle of October.

18. By a southern route.

20. They feed on a slimy substance which comes from the bottom; it looks like a discoloration of the water, but is composed of vegetable or animal matter; the large bodies break into small ones at night and go near shore; in the morning they gather again and go out.

21. At the heads of rivers and creeks, and near fresh water. They spawn in June and July.

24. The water must be warm.

26. I think they float.

28. They are found in abundance in shoal water, where the fresh and salt water mingle.

29. No.

30. Bluefish and porpoises destroy them, but the parent fish do not.

31. Crab-lice are found in the gills, and there is a five-pronged insect, which makes a sore, seen in the tail; we call these insects graplings.

32. They suffer greatly, but are very active; the bluefish is their worst enemy.

33. Never knew of it.

34. Haul-seines, purse-nets, gill-nets, and weirs.

35. Haul-seines are 100 fathoms long and 8 feet deep; nets are 200 fathoms long, and from 18 to 20 feet deep.

36. Barges are mostly employed, and vessels of from 10 to 20 tons burden.

37. Twelve men for purse-nets and 25 for haul-seines; one man for gill-nets.

38. All hours of the day and night. Gilling is done at night.

39. No.

40. Yes; it scatters and sends them down deep.

41. Five vessels averaging about 15 tons, and 5 barges.

42. They are made into oil and manure, and sold to farmers.

43. Tangier belongs to Crockett & Co., Manokin to Ford, Avery & Co.

44. About 800 barrels at Ford's, and 500 at Tangier.

46. The fish are boiled in large kettles at Tangier, but are crushed at Manokin. The Tangier and Manokin factory cost each $2,500.

47. Fifteen cents per bushel.

48. About 1,000 fish, or from 4 to 4½ bushels.

50. One quart, and is least in July.

51. One and one-half gallons, and is greatest in August and September.

52. Yes, as much again.

54. Philadelphia and other cities.

55. Home.

56. Used for lubricating purposes.

57. From 40 to 60 cents.

58. Yes.

---

61. *Statement of Isaac D. Robbins, Hog Island, February* 21, 1874.

No efforts are made here to catch the mossbunker. We have them during the largest part of the year, from April to September, and sometimes in winter. I once saw many of these fish in Swangut Creek which had died from the effects of hot weather; they were then about 2 inches long. In the fall we see them from 3 to 5 inches long. We make no use of these fish, but I have an impression that there are enough of them to make our land very rich if they were made into manure.

On the Chesapeake side of the peninsula I have known large quantities of these fish caught, and a few years ago some gentlemen undertook to convert them into oil and manure, but to what extent they were successful I cannot say.

The grown mossbunker is from 9 to 12 inches long, and generally very fat.

---

62. *Statement of J. L. Anderton, Apateague Island, Virginia, January* 12, 1875.

1. Alewives.
2. They are more abundant than any others found in this vicinity.
3. Increased.
4. There is no establishment in this vicinity.
5. It does not in this vicinity.
6. First seem to come near the coast in April. The main body appear in June. The first are the smallest.
7. They swim high, make a ripple on the water, and attract birds.
8. They come from a southward direction.
9. Their appearance is regular and certain.

10. No.

11. They come nearer the shore on the flow of the tide and move off on the ebb.

12. On bars and in coves.

13. Four and a half to five feet. They swim nearly to the top of the water.

14. It does.

15. They come before they are mature, and we find the one and two year old fish with the oldest.

16. They are seen on the coast from April till June, from 4 to 10 inches in length.

17. They leave in November by degrees.

18. They go southward.

19. Somewhere south, I think.

26. I think they float.

29. Yes.

30. Don't think the parent fish devours them ; birds eat them.

31. Lampreys are sometimes found attached on the outside.

32. Quite considerable.

33. I have not noticed any.

34. None in this vicinity, except small gill-nets.

42. There are but few caught in this vicinity. They are used on the spot.

---

63. *Statement of G. Henry Seldon, Kinsale, Westmoreland County, Virginia, August*, 1874.

1. Alewives.

2. More abundant than any other fish.

3. Diminished very much within the last ten years, particularly in the small rivers.

4. From 5,600 to 6,000 barrels taken in 1873 by one establishment in this vicinity. This is about the average number of barrels taken each year.

5. The capture has a tendency to affect their abundance.

6. They appear in Chesapeake Bay about the 10th of March. The main body arrives about the 15th of April. The first fish are the largest. They come in quick succession.

7. They appear in schools, but swim low. There is therefore no ripple seen, and their arrival is known only by their capture, and the attraction of birds.

8. They come up the coast from the south; their movements are very swift, passing to the headwaters of the bays and rivers, where they are seen to linger a short time to spawn; then returning, they leave our coast and go to the coast of New England.

9. They are never known to fail.

10. They do not appear to be scared by seines or nets any longer than they are in sight of them.

11. Their migration is more on the ebb tide, as they stop on the flood tide to feed.

12. In large bays and rivers where the bottom is soft.

13. From three to eight fathoms of water. When the weather is cool they swim deep, but come near the surface at times; these times can be ascertained by the birds striking them. When the weather is warm these fish are seen to swim with the tops of their heads out of the water.

14. As the mercury sinks they swim deeper in the water.

15. They seldom appear on their breeding grounds before matured. The one and two year old fish are not found among the oldest.

16. The young fish are seen on the coast about the 1st of June, at which time they are about 4 inches long.

17. They leave the coast generally in the latter part of October in a body.

18. They leave the coast by the southern route going south of course.

19. It is thought that they spend the winter in or beyond the Gulf Stream, where the water is warm.

20. There is a sediment upon which they feed; this they purify by straining it through their gills.

21. They spawn in the headwaters of our bays and rivers, generally in the month of April.

22. In their migration movements they are mixed indiscriminately, as may be seen from the manner in which they are caught in the gill-nets; but when coming upon the breeding grounds, they are not huddled in schools, as may be seen afterwards.

23. The milt of this fish does color the water.

24. Cannot tell the exact temperature of water which is most favorable for spawning, but I think when it is from 45° to 65°; when the water is cold they spawn in the deep where the cold winds cannot chill the spawn; when the weather is moderately cold, it does not destroy the spawn, but the young fish will not hatch as soon as when the water is of the right temperature. Where the water becomes heated by the burning rays of the sun the spawn is instantly destroyed.

25. In from 4 to 10 feet of water; the eggs lay on the bottom. Where it is soft, and produces a little grass, it is all the better for the spawn.

26. When the eggs are spawned they sink to the bottom, but become attached neither to stones, grass, nor any thing of the kind; neither do they float until hatched, but lay on the bottom.

27. In four or six days' time after the eggs are laid they begin to hatch out. It has been said that they hatch out in two days after they have been laid, but this is very seldom; however it is not impossible, but my own experience teaches me that to hatch them out in two days would require the tide, locality, and temperature of the water to be very favorable.

28. The young of this fish are found in great abundance in the head-waters of our bays and rivers, generally near the shore.

29. The spawn is never known to run from this fish while being handled after they are captured.

30. The parent fish does not destroy the spawn, but other fish, such as the rock-bass and the pickerel destroy the spawn of this fish.

31. The lampreys are often found attached to the outside of this fish. In their gills and roof of the mouth is found an insect as large as the end of a man's small finger and three-quarters of an inch long. This is the small size of this insect. I have seen them an inch and a quarter long. It is transparent and has a tail resembling that of a lobster; and so great is the adhesive power of this insect, that you might attach one of them to your finger while it is alive and you could not throw it off. This insect is known to us as the fish-louse, because it attaches to the inside of the head of this fish; they are known in many localities as the buggy-head fish.

32. The bass, trout, bluefish, sharks, and the porpoises all feed upon this species of fish.

33. No disease of any description has ever occurred among them, causing death in any numbers worthy of notice in the past thirty years.

34. Purse seines, gill-seines, haul-seines, fike-nets, and hedge-nets are all used in capturing these fish, and are generally used with great success.

35. Seines for capturing this fish are from 50 to 400 fathoms long, from 2 to 5 fathoms deep, and of a 2 or $2\frac{1}{2}$ inch mesh. The seines used at the oil factories are called purse-seines; they are about 100 fathoms long and 500 deep.

36. Small-size schooners and sloops, being from 6 to 20 tons burden.

37. Two men to each vessel, except the tug, which has 5 men.

38. Toward midday is the most successful period for catching these fish.

39. They are taken in greater numbers on the ebb tide.

40. They do not appear upon the surface of the water in windy as they do in moderate weather.

41. Seven vessels are employed in this vicinity having crews of 15 or 18 men, but the aggregate number of men at the factory and on board of the vessels is 45 or 50.

42. The fish thus caught are taken to the factory and there boiled up for oil.

43. The only factory in this neighborhood is the one at New Point Comfort, owned by Nickleson & Co., of Norfolk, Va.

44. The average quantity of good oil produced by this one factory is about 300 barrels a year.

48. One bushel.

49. Probably 10 gallons.

50. Probably $2\frac{1}{2}$ gallons in the spring and summer.

51. Probably 3 gallons. The greatest quantity of oil is obtained in and after the month of September.

52. Yes.

54. New York.

55. Virginia and North Carolina.

56. For tanning leather, painting, machines, &c.

58. Yes.

---

64. *Statement of Henry Richardson, Cape Henry, February* 9, 1874.

1. The "alewife," termed by some "bony fish."

2. These fish are more numerous than any other fish that inhabit these waters.

3. During the last four years (the length of time I have been in charge of this station) there seems to be no diminution in the numbers of these fish.

6. These fish are caught as early as March, but the main body arrives about June and July. During these two months these fish are constantly passing the Virginia capes, entering the Chesapeake Bay. I have seen schools of these fish on calm days in the summer season, I should judge, about two miles long and perhaps one-fourth of a mile wide.

7. These fish swim high, or near the surface of the water, and their approach can easily be seen by the commotion they make. They ripple the water and also attract the attention of birds.

8. They work in the spring of the year from south to north. I do not know their subsequent movements after their entrance into the Chesapeake Bay.

9. I have never known these fish to fail to enter these capes during any season.

11. During the summer season they work in and out of the capes, working out with the ebb tide and working in again on the flood.

13. They swim in shoal as well as in deep water, and create a constant flipping on the surface.

14. In unusually cold weather they get benumbed, and sometimes wash on shore in great quantities.

16. The young fish commence coming about June, and average, I should think, about five inches long.

18. They follow the Atlantic coast and work south.

19. I have been informed that they winter around the Bahama Banks and the West India Islands.

20. Their flesh is very sweet early in spring and late in the fall of the year, but they are objectionable as food on account of the quantity of bones they possess.

31. In the summer season they become wormy. These worms have the appearance of a fine piece of red string about one inch long. I have pulled them out of the side of the fish, and the root or end of the worm in the flesh has the appearance of an eagle's claw.

34. A purse-net; although they are caught in large quantities frequently in the summer season with long seines. These seines are used for catching the more edible species of fish, and when "alewives" are caught by these seines they are left to rot on the shore.

42. These fish are caught about the entrance of the capes or in Chesapeake Bay, put on board of the small schooners employed in this business, and thence taken to the factories, where the oil of the fish is extracted and the refuse manufactured into fish guano or fertilizer.

43. At the present time there are no factories for the manufacture of fish-oil in this neighborhood. A factory for this purpose was in operation some two years ago, but it has since been consumed by fire.

58. There does not seem to be any diminution in the quantity of these fish, and thousands of bushels are annually destroyed on this coast by the seines used in catching the more edible fish that supply our markets. They might be used to good advantage in manuring the land in the surrounding country, but the difficulty of transporting them to lands used for agricultural purposes is so great that they are left on the beach to rot.

---

65. *Statement of C. G. Manning, Edenton, N. C., January* 6, 1875.

I have the honor to acknowledge the receipt of your circular-letter under date of December 23, 1874, making inquiries relative to the fish known in our vicinity as fat-back or bug-fish, and in reply thereto I would state I have conversed with several of the leading fishermen on the Albemarle Sound and its tributaries, and they report very few of that class of fish caught during fishing season. Those which are caught are disposed of by being thrown in with the offal or refuse fish, afterward used upon their lands in a raw state as fertilizers.

The fishermen attribute the scarcity of that species of fish in the upper part of the sound to the freshness of the water. I have been unable to obtain any information from the lower part of the sound, where the water is brackish or salt.

1. Bug-fish.
2. They are very scarce.
3. Diminished.

---

66. *Statement of A. W. Simpson, jr., Cape Hatteras, N. C., April* 15, 1874.*

1. Fatback.
2. It is not found throughout the year. It makes its appearance in June and leaves in December.
3. It is not resident.

---

* The numbers of this communication refer to the general circular published in the first volume of the report of the Commissioner.

4. It is more abundant than any other fish that frequent the waters of North Carolina, say 5 to 3.

5. They have increased in abundance within the last ten years.

6. The supposed cause is that their enemies are not so numerous.

7. The amount or extent of the change in abundance cannot be ascertained.

8. The greatest length to which this fish attains is about 16 inches.

9. The rate of growth per annum, &c., is not known by any one in the community, no attention being paid to it.

10. The sexes differ somewhat in shape and size; the male is as long but not so large as the female.

11. These fish generally come in to the shore on the northern coast, and run along the beach south, running into the different inlets. In the first of the season they may be seen, in moderate weather, five or six miles at sea in large schools, half a mile long and all along the coast, lying apparently at ease floating upon the surface of the water. This habit they indulge in until the latter part of October, when the bluefish or taylor arrives; then they seek protection in the surf near the beach, and are washed ashore by thousands. I might be safe in saying hundreds of thousands are washed ashore in one night or during one flood-tide.

12. They continue to run south, or rather are driven by the taylors until December, after which only a very few are seen in the sound.

13. It is unknown to any one here where they spend the winter season.

14. The fish come near the shore upon their first arrival on the coast, but the main body does not come in until driven in by the taylors and dogfish about the first of November. The first are generally the smallest. I think they are continually on the coast from the time of their arrival to the time of their departure; but sometimes they are seen in larger quantities than others, say once to twice a week.

15. In some seasons the fish leave the shore in a body, and at different times during the season; but when they leave the coast for the south they go by degrees, commencing about the first of December.

16. The appearance of these fish in the sound, and at sea off the coast, is certain every season; but they only come near the seabeach when driven in by the taylor and dogfish.

17. The runs do not differ, except in quantity. Some seasons the runs are very large in October; but in November they are not so plentiful, and *vice versa*.

18. As far as my knowledge extends, both sexes come in together. The spawn is about two-thirds developed when they first arrive.

19. These fish never take the hook.

20. These fish never take the hook.

21. The schools of fish swim high in moderate weather, but in high winds and rough seas they run in deep water. Their arrival is sometimes known by the schools which are seen at sea, lying at ease appa-

rently, with a continual flipping motion with the tail above water; this attracts thousands of birds.

22. They generally come on the beach on flood and drop off on ebb tide; they also run into inlets on the flood.

23. Spawn is sometimes seen when the fish are handled to any great extent.

24. The spawn is also seen around set-nets, when the fish force themselves through the meshes.

25. The fish are anadromous; they run up the fresh-water rivers for the purpose of spawning, and to "suck" (eat) the scum generally brought down by freshets.

26. They sometimes make several trips up the rivers, and returns in the sound, before going up to spawn; this is attributed to the number of freshets during a season. Some seasons they make no stay in the sounds, but go right up the rivers on their first arrival, and continue these visits until December.

27. See answer to question 26.

28. There is no difference in this respect as to sex or age known to me.

29. The young fish are generally mixed up with the old ones when in large bodies or schools; but, as a general rule, the young are seen along the shores of rivers and sounds.

30. The favorite localities of these fish are varied as in other cases. In moderate weather they float high, in fact upon the very surface of the water, and feed upon the scum or mud which are afloat. They then select some place near a lead or tide way, but often shelter themselves behind a shoal or breaker where the current eddies; but in windy and rough weather they are constantly running.

31. They generally prefer the deepest water to school, as stated in answer 21.

32. There has been no difference observed, by me at least, as to the favorite temperature of the water, but they are more abundant when inside the sound in thick, milky-colored water.

33. These fish are not seen in schools after they are done spawning; but the general opinion is they are in schools when leaving the sounds and rivers, judging from the quantity taken or caught in set nets of a night. They are not seen at all in moderate weather, as described in answer 21.

34. They have no special friends; but the porpoise, the shark, the dogfish, and the taylor are special enemies of the old, and the crab, the eel, the perch, trout, and several other species of fish, of the young fish.

35. The fatback do not prey upon or eat any other species of fish during their stay in this section.

36. They suffer to a great extent from the attacks of other fish, but the amount is not exactly known. I think, however, I would be perfectly safe in saying that at least half are destroyed.

37. The nature of their food is mud from the fresh-water rivers, scum, &c., afloat on the water, and marine insects, which are found along shore and on the reefs in the sounds and rivers.

38. There are no special peculiarities in the manner of feeding these fish known, no attention having been paid to that particular.

39. Nor is it known what amount of food they consume. When taken, the stomach or pouch is generally full of mud, and they are very fat until they have spawned.

40. The sexes differ somewhat in color and shape during the breeding season, the male being of a pale-yellow and the female a bright-yellow color in respect to their fins and tails. The male is equally as long, but of a more straight shape. The edges of the females are generally tinted with bright-yellow specks.

41. There are no special or unusual habits of these fish during the spawning season known to me.

42. Lines and nets interfere somewhat with their progress up the rivers, but aside from this spawning is not interfered with to any great extent by lines and nets.

46. According to my views, from their movements and not from actual knowledge, these fish deposit their spawn in the beds of the principal rivers—the Neuse, Tar, and Roanoke—about the last of November.

47. I can give no account of their process, &c.

48. The water is sometimes whitened by the milt and spawn.

49. They generally select the warmest places for spawning, but the exact temperature is not known; it varies from one to ten degrees, owing to the weather.

50. The eggs are laid in two to three fathoms of water, and supposed to lie on the bottom.

51. The spawn is of the size of a mustard-seed, and of a light-red color.

52. The number for each fish has not been ascertained.

53. Either for one season or for lifetime.

54. The eggs when spawned sink to the bottom, but whether they become attached to stones, grass, &c., I do not know.

55. It is unknown whether the fish heap up or construct any kind of nests of sand, gravel, or grass.

57. It is not known by any one on the coast when the eggs are hatched or in what period after they are laid.

62. They are never seen carrying them in their mouths or otherwise.

63. The crab, eel, perch, trout, and several other species of fish destroy the spawn and the young fish. The parent fish never interferes with either.

64. The young of this fish are found in great abundance on the shores of rivers and sounds.

65. They appear to feed the same as the old ones, as described in answer 37.

66. No steps have been taken to increase the abundance of this fish by artificial culture.

67. These fish have no protection from any source.

68. No epidemic or other disease has ever been noticed among them on the coast.

69. If such has ever taken place, the time and cause are unknown.

70. Worms and lampreys are found in the gills and about the fins of these fish.

71. The fish are caught in nets.

72. For ordinary purposes in set-nets of from 50 to 60 yards long, $1\frac{1}{2}$ to $1\frac{3}{4}$ inch mesh, and from 20 to 30 meshes deep. These nets are generally set at night with both ends made fast, and remain in the water during the entire night, so the fish are caught in the night-time. But when they are caught for the purpose of manufacturing into oil and manure, they are hauled ashore at the inlet and on the sea-beach with large seines, or taken with purse-nets. This latter performance can be done more effectually in moderate weather when the fish are in schools.

73, 74. It may be taken in nets from the 1st of October to the 1st of December. They are never taken with hook.

75. One good seine, of proper size to suit the depth of water, might haul ashore in a day at least 100 barrels of fish along the beach. This is only at times when the tailors drive them in to the beach. In some seasons we might get ten, in others not more than two, good days' fishing.

76. A purse-net will take of a good day 15 to 20 barrels, while a set net only 4 to 5 in a night.

77. It is caught more on flood-tide than on ebb, for they go off shore on ebb-tide.

78. The fish caught are used on the apot, except occasionally some are taken at sea in purse-nets by vessels connected with some oil-factory on the northern coast.

79. It is an excellent food, fresh or canned and smoked.

80. It sustains its excellence as a fresh fish only a short time, owing to the temperature of the weather.

81. It is eaten to a great extent by the fishermen and others along the coast.

82. It is salted down in quantities only to save from one season to another.

83. It has been used for oil and manure to some extent, but there is no establishment of this kind on the coast at present.

84. These fish are not carried to market in any abundance, but when any are sold they are worth from $8 to $10 per thousand. The prices vary according to the quantity of fish in market.

85. These fish have never been exported from North Carolina.

86. The principal market of the fatback is in country places among farmers and freedmen.

67. *Statement of A. W. Simpson, jr., Cape Hatteras, N. C., January* 20, 1875.

During the past season the fishermen provided themselves with seines and boats in time to meet the first run of the bluefish. The seines were made of cotton marlin, and were about 100 yards long, 2½-inch mesh, and from 40 to 50 meshes deep. The bluefish made their first appearance on the coast from the north. The menhaden passed about three days in advance of the bluefish. I do not think I ever saw so many of this species at any one other time or in any one other season. From the balcony of the light-house at least twenty-five schools might have been seen lying along the coast, both north and south of the cape. Each school seemed to cover many hundred yards of surface and to be moving south at the rate of from four to five miles an hour. This continued, and school after school followed, for ten days before the appearance of the blue-fish, and when the blue-fish did appear there seemed to be more of the menhaden with them than had passed the station during the three previous days. Hundreds of barrels, I think, were washed ashore, and were driven so close by the bluefish that they had not the power to resist the surf, which was quite rough and heavy, and they were consequently thrown ashore upon the beach. Only a very small quantity of these fish were saved, as the fishermen gave their attention more particularly to the bluefish; but some of them were saved and salted down, when they were sold to a good advantage. Some sold as high, in trade, as to bring ten bushels of corn, equal to $7 in currency, for one common fish-barrel of the menhaden. It has been generally thought by old, experienced fishermen here that the bluefish drive the fatback south in winter; but I have learned differently during the past season from personal observation, which the following fact strongly attests. The menhaden came three days in advance of the bluefish, and entered the sound at all the principal inlets, and made their way directly for the fresh-water rivers. They could be seen as numerous in the sound, heading north, as they were in the sea heading south. Furthermore, by a letter from a gentleman of Plymouth, N. C., I hear that they passed that place, eight miles above the mouth of the Roanoke, in five days after passing this station, and by another letter, from Windsor, 38 to 40 miles above the entrance, I hear that they arrived there as early as the 18th of December. Thus it may be readily seen that the bluefish are not the cause of the fatback coming south. I would sooner think that the fatback caused the bluefish to come south in winter, as they generally follow in the run and among the last of the run of the fatback.

Last year there were not so many of the menhaden, but there were millions of young spat—about two years old; however, this winter there was not a spat to be seen, but the gray trout came instead. These, too, were washed ashore in great numbers. I feel safe in saying that if

the fishermen had provided themselves with material for saving menhaden and trout, there might have been double the sum realized that there was by bluefish, although there were very many bluefish caught. There were engaged on the coast of Dare County twenty-five to thirty boats, each boat containing one seine and three men; these were scattered promiscuously along the coast, and, I think, from a rough calculation made since I wrote you last upon the subject, that the catch for the season averaged about two thousand to each boat and crew; making in all over fifty thousand bluefish. These fish sold for from fifteen to as high as fifty cents each. I have not heard of any being sold for less than fifteen cents cash. Many of them were traded off for corn, flour, and such other articles as this place does not produce. I think that there will be very extensive preparation made for this business next winter, and also for the menhaden. There is no needs of making any preparation for catching the menhaden; more will be driven ashore than can be saved.

---

68. *Statement of A. W. Simpson, jr., Cape Hatteras, N. C., January* 25, 1875.

1. Fat-back.

2. Heretofore only about one-third more abundant than any other species, but I have seen twice as many fat-back during the fishing season of 1873 as I ever saw of any other species on our coast.

3. It has increased.

4. Only about fifty barrels.

5. Neither capture nor the destruction of the fish on the coast by the bluefish seem to affect their abundance.

6. There are generally two runs; in other words, the fat-back comes south in spring, and some are seen in the sounds and rivers all the year; but when they come south for the purpose of spawning, they come sometimes in November and at others in December. In 1873, they were first seen on the coast about the 6th of December, and the main body arrived about the 10th of December. I did not notice any difference in the size of the fish in the different runs. There are generally more schools than one; many schools may be seen at one time. They seldom come near the coast in high winds and rough seas, but when they do, they swim so low that they are not seen from land.

7. The schools of fish swim high in moderate weather, and low in high winds and rough seas. Their arrival is generally known by the birds and by the ripple they make on the water. They are a great attraction for birds.

8. I do not know by what route they come into the coast north of this place; they come down along the coast from the north, enter the sounds at the principal inlets, and go up the rivers at once; they generally go from four to five miles an hour.

9. The appearance of this fish on our coast is certain, and they are

about the same as to abundance every year, when the spring run comes in; but the fall and winter run varies somewhat; some seasons not half so many are seen as at others. I do not know of any real cause for this difference.

10. Only for a short time; they will return to their feeding-ground in less than two hours after having been scared away by a net.

11. In winter I do not think the ebb and flow of the tide affect their movements any more than they choose to run against the tide. More of them enter the sounds from sea on ebb than flood tide. In spring and summer they frequent deep water on the ebb and shallow water on the flood tide.

12. During spring and summer they feed in muddy slues and channels on the ebb and grassy reefs and shoals on flood tide; in moderate weather, during the day and at night, they seem to drift up and down the channels and sounds with the tide, either ebb or flow, and in high winds they are continually running.

13. They do not seem to be particular about the depth of water, as some at their feeding-ground are in deep channels and others are in shallow slues. They swim on the top of the water in moderate and near the bottom in stormy weather.

14. They prefer the warmest water.

15. From what I have been able to learn they do not come on the breeding-ground before they are mature. Some small fish are seen in large schools, but not as a rule; the one and two years old school are by themselves.

16. The young fish are seen in the sounds, creeks, and rivers all the summer, from one to three inches long. I remember, one day during last August, twenty-five miles above New Berne, I could see 50 schools at once, from one to three inches long, and I noticed they were more numerous nearer the mouth of the river; these come down on the coast, and feed along the shores of the sounds and in the creeks until they are large enough to go to sea.

17. I think they have various ways for leaving the coast; some seasons they may be seen going to sea in large schools, and at other times they go off gradually. They leave by two runs; those that come in November or December leave about the middle of January, and the spring run leaves in October.

18. They return north by the same route they came south.

19. They spend a part of the winter in our principal fresh-water rivers, and in the sounds and creeks; where they go after going to sea I do not know.

20. Mud and scum from the surface of the water and insects which they find among the sea weed or grass is their principal food.

21. These fish spawn in the Neuse, Pamlico, and Roanoke Rivers some time during the month of January.

22. From what I can learn they are mixed indiscriminately.

23. The water is colored to some extent; it being already of a milky color, it is hard to ascertain; but it is colored some by the milt of the male.

24. I do not know the exact temperature.

25. The eggs are laid on the margin of the river, generally in from 6 inches to 2 feet depth of water.

26. The eggs float about the river; some of them are even seen to drift ashore, when the water falls away, leaving them dry; this destroys them.

28. The young are found is great abundance in the rivers, sounds, and creeks.

29. Fishermen on the rivers say that the spawn runs from the fish when handled after having been in fresh water two to three days; but it never happens while they are in salt water.

31. Lampreys are sometimes found attached to the gills, and a kind of a bug in the roof of the mouth; but I never heard of crabs being attached to them.

32. They must suffer to a great extent from the attacks of the bluefish, shark, and porpoise. I noticed that each bluefish caught on the coast this season had from one to three fatbacks in the stomach, showing that many thousands, and I might say millions, are destroyed by the bluefish alone.

33. I have never known of any epidemic among the fatback.

34. Drag-nets at the sounds, and set-nets at the rivers. These are made of gill-twine, No. 25 or 30, and cotton warp spun into cord.

35. The drag-net is from 75 to 100 yards long, having a mesh of from 1½ to 2 inches, and from 25 to 35 meshes deep. The lower or lead line is kept on the bottom by sinkers made of lead for the purpose; and the upper or cork line is kept on the surface of the water by floats made of dry gum-root made for the purpose. The set-net is made of gill twine, of from 35 to 45 yards long, and from 18 to 20 meshes deep, the mesh being from 1½ to 2 inches. A coarse selvage made of cotton twine, dipped in tar and then dragged or rolled in coarse pebbly sand, answers the purpose of lead sinkers. A cork line buoyed with gum-root corks keeps the net off the bottom. These are called fly-tale nets. They are placed in the water on the feeding ground in the evening, and allowed to remain all night.

36. Canoes (not tonnaged) are used; some of them are only 16 feet long by 3½ feet wide, while others are 30 by 7.

37. Two men are sufficient to manage the small canoe, and three the larger ones.

38. Both day and night flowing water is preferred.

39. They are taken more plentifully in the flood-tide.

40. Moderate weather is preferred for fishing with the drag-net, and high winds for the set-net; as they are feeding in moderate and running in windy weather.

41. There are no particular number employed in catching the fatback, as that is not made a specialty. The fishermen in this vicinity have nets to suit, and look after all kinds of fish. About 200 boats are employed in the two townships adjacent to this station, with an aggregate number of men amounting to about 500.

42. Some of the fish caught during winter are used on the spot, and some are carried to the country towns, villages, and farming districts and sold, while those caught in summer are used for manure.

43. There are no oil-factories here.

47. Seven dollars per barrel was paid for menhaden in 1873. I have no account of previous years.

58. The catch does not appear to diminish them.

---

69. *Statement of Wallace R. Jennett, Cape Hatteras, N., C. February* 26, 1874.

1. Menhaden and Fatback.

2. They are more abundant and less cared for than any of the finny tribe.

3. They are not so abundant as ten years previous.

6. They arrive in October and November principally, and may be found to be larger at the time of their departure.

7. The fish generally are seen upon the surface of the water so as to attract birds.

8. They come from the north, caused by the prevailing winds at that season of the year.

9. Yes.

10. They seem nowise sly, and are very regularly driven from the regular course.

11. On the ebb and flood alike; they are seen to float without any material difference, having no particular favorite locality.

13. They prefer deep water, and are, so far as we can see, not affected by the temperature.

15. The fish on their arrival seem to be of the same age and size, no young fish are seen at all.

17. They leave in the early spring and go south.

20. Sediment and mud from the water and fine grasses.

22. The fish seem to mix indiscriminately; the sex is hardly to be observed at any time; it is not likely that they spawn on this coast at any time.

23. The water very rarely changes its color among the fish, consequently no milt is discharged.

28. There are no young fish found in this locality.

29. The spawn is never seen to run from the fish as from the shad, rock, perch, and others.

31. Crabs, lice, and other living animals are found attached to them at times in the gills and on the backs.

32. They fall an easy prey to sharks, bluefish, and porpoises; thousands are thus destroyed, furnishing food for other fishes that may follow in their track, such as drums, trout, &c.

33. Epidemics and distempers are very rare, but are sometimes prevalent; at which time they have drifted ashore in such abundance that the stench has been fearful.

34. They are caught and taken with immense purse-nets, made of cotton twine, 200 fathoms long by 25 to 30 feet deep.

36. Sloops or cat-boats are used to carry seines and men, at least 3 or 4 in number, with an aggregate of 25 men.

38. The entire day is often used in catching these fish.

40. The wind at all times seems to affect them, as they are seen frequently running before it, and in quick motion.

41. At the present time there are no arrangements made to capture the fatback. The business has not seemed to pay, for want of transportation.

42. The fish when caught were used on the spot. The oil was pressed from them by hydraulic press, and the refuse was used as fertilizer.

58. It is probable that the fish caught does tend to diminish their numbers and quantity.

---

70. *Statement of A. C. Davis, Beaufort, N. C., February* 14, 1874, *and January* 27, 1875.

1. Fatback.

2. More abundant than any other species.

3. Increased.

4. No establishment in 1873; cannot state for other years.

5. Does not.

6. In June; main body arrives in July; increase in size after arrival, and are largest in October. Schools are constantly coming in (in the season) at short intervals.

7. Swim on the surface except when disturbed; they then sink, and in a short time reappear. Arrival is known only by their appearance in schools on the surface of the water. This latter, perhaps, may arise from the fact that about the time of their first appearance no fishing is carried on by nets; it is, however, generally considered that their arrival is first known as stated. They make a distinct ripple on the water, and are easily known from other fish. They attract birds, &c.

8. Southward, ascend the rivers, drift in schools up and down with the ebb and flood tides.

9. Regular and certain; they have never failed; seem to return in greater abundance; perhaps this is due to the fact that only a small quantity have been captured yearly in this locality.

10. Are taken by nets, &c., inside the inlets; are easily taken. The

use of nets does not scare them further from the shore, but the rivers are not very wide.

11. Always swim or drift with the tide.

12. In the channels of the rivers.

13. The deepest; when attacked they swim near the bottom.

14. Are not seen after October, or, say, early in November.

15. Do not breed here; they arrive here one-fourth to one-half grown; neither two-year old fish nor the oldest arrive at their first appearance.

16. Not less in size than named in 15.

17. Main bodies in October and early in November, by degrees.

18. Proceed south.

19. Southward.

20. Having no teeth, they feed off the slime, scum, &c., on the surface of the river.

21. Further south; cannot say where. I have given this matter some attention, and from what I consider the best information they spawn at sea, not in the rivers, early in the spring.

22. No. On their appearance in the rivers the sexes are mixed indiscriminately.

23. Is colored late in the season, but is only noticed at the time of the "catch" or "take."

28. Not in this locality.

29. Has been found to run in a late catch.

31. Not.

32. Severely from sharks, slightly from porpoises, late in the season; when at the inlets they are attacked by bluefish.

33. Never has.

34. Cotton and gill twine nets, after being partially worn in taking other fish, are unfit for further use after the first season; slime, &c., rot them.

35. Generally 50 fathoms in length; 50 to 60 meshes, of $1\frac{1}{4}$ inches to $1\frac{5}{8}$ inches per mesh, deep.

36. Open boats and canoes only, carrying from 10 to 25 barrels, are used in this locality.

37. Two (2) men to each canoe and net. In making what is called a drop or haul, 4 to 6 nets are used. The school is surrounded, the fish are meshed in the net, shaken from the nets into the boat or taken out of the meshes by hand. The fish are never hauled to the beach.

38. One haul generally loads the canoe; two loads can be made in one day; the time occupied for each load is from 2 to 4 hours.

39. More on the ebb.

40. Are more numerous in moderate weather with southerly winds.

41. Only boats and canoes, as named in 36. Very few were engaged in the business, though enormous quantities of the fish were present in the rivers, during this last season.

42. At this time only, for agricultural purposes on the spot. None are sent abroad.

43. None.

47. Fifty (50) per barrel of $3\frac{1}{2}$ bushels. In previous years, 60 to 65.

50. Three-fourths gallon to 1 gallon at the first run in June.

51. Four gallons to 5 gallons in October and early in November.

52. Are one-fourth larger and yield more.

53. Three manufactories have been established (several years since); but all have suspended operations.

55. Scrap was sold principally at Baltimore and other northern points.

56. Is excellent for mixing with tar, ochre, &c., for painting roofs of houses, also water craft. It is also valuable in applying to cattle, hogs, &c., for the extermination of vermin.

57. In previous years 75 cents per gallon.

58. Does not.

---

71. *Statement of W. T. Hatsel, Body's Island N., C., March* 4, 1874, *and February* 23, 1875.

1. Fatback.

2. There are three times as many.

3. Neither diminished nor increased (diminished 1875).

4. Fifty thousand barrels in 1868; Excelsior Works at Ocracoke Inlet; Adams & Co., Beaufort, N. C.; and Church & Co.

5. No.

6. There are two main bodies; one in the spring (April), another in the autumn (October).

7. They swim high and make a ripple, which attracts birds.

8. North and south.

9. Sometimes they fail for a season.

10. No.

11. They scatter at the flood.

12. Around inlets near the shore.

16. Yes, between first and last; approach 3 inches long.

17. In very cold weather.

18. Southward.

19. Somewhere south.

20. They live by suction.

21. In the sounds.

23. Yes, it is colored white.

26. They are supposed to sink.

29. Sometimes.

30. Sharks, porpoises, and bluefish. If the parent devours them it must be done when quite young, or at spawn-time.

31. Worms are found in the gills and outside; lampreys are also found outside.

32. They suffer very much.

33. What the nature of the epidemic is, I cannot say; I have known them to die to some extent.

34. Purse-seines.

35. Five hundred yards long and 50 deep.

36. Cat-boats of 6 tons.

37. Seven men.

40. They move against the wind.

41. I believe there are none in the State.

42. Used for oil and scrap; the oil is sent to New York, the scrap to Baltimore.

43. There are now none.

46. The Excelsior Company's cost $30,000; Church & Company's cost $5,000; Adams & Company's cost $5,000.

47. Twenty-five cents.

48. One barrel of fish produces 1½ gallons of oil.

49. Seventy-five gallons.

52. Yes.

54. New York.

55. Baltimore, Md.

56. For tanning purposes.

58. Does not perceptibly (1874). Yes (1875).

---

72. *Statement of W. A. Harn, Morris Island, S. C., January* 21, 1875.

In reply to circular dated December 20, 1873, requesting information of fisheries and the habits of fish on this coast, I would say that there are no fisheries near this station, and the only fish that are caught here are the whiting, trout, and sheephead, and those in very small numbers.

---

73. *Statement of Patrick Conner, Daufuskie Island Light, S. C., March* 15, 1875.

1. Mossbunker, or bony shad.

2. There are five hundred thousand per cent. more than any other.

3. It has increased.

4. None.

5. There is no capture of them to have any effect.

6. In May. The main body come in June; they are; there are.

7. They swim high, make a ripple, and attract birds.

8. I know not their route; they come into the sound and go out with the tide.

9. It is. I never knew them to fail.

10. I cannot say. I never saw them caught.

11. They come in with the flood and go out with the ebb.

12. The bayous along the coast.

13. I do not know. I have seen them in all depths, from 3 feet to 6 fathoms.

14. It does. They never come before it gets warm in May.

15. They do; yes, but generally they go in schools according to size.

16. They are, in July and August, about $1\frac{1}{2}$ inches long.

17. They leave in September; in schools and by degrees.

20. Some sort of insects, or it may be their own eggs; they are constantly sucking in the tide.

28. They are in all the bayous along the southern coast.

30. I cannot say what enemies the spawn has; but shark and bluefish destroy the young.

31. There is a bug, with several feet or legs, found outside on the cheek.

32. They suffer heavily; but, on account of their very great numbers, are scarcely perceptibly diminished.

33. I do not know of any.

34. No kind. These fish are never captured.

35. There are none used.

36. No vessels employed of any tonnage.

40. High winds do; the small ones are cast ashore in rough weather.

41. None.

44. None.

45. None.

47. None bought or sold.

53. It has no history. There is none manufactured.

54. There is no market, for there is no oil.

55. There is no market; there is no scrap.

58. I cannot say; they are never caught.

---

74. *Statement of George Gage, Beaufort, S. C., January* 20, 1874.

Referring to your circular of December 20, 1873, relative to the "menhaden fisheries," &c., I have to report that I have no evidence of the existence in this district of either of the species of fish therein referred to. There is no fishing here in a commercial or statistical sense.

---

75. *Statements of Joseph Shepard, Saint Mary's, Ga., March* 30, 1874, *and January* 28, 1875.

I have the honor to state, relative to the species of fish known as the mossbunker, that after making inquiries of men who have made a business of fishing on the coast of Georgia and South Carolina, and who have fished for the mossbunker farther north, that none of that species

are found south of Cape Hatteras. I may mention that only one instance of the mossbunker being taken here has come under my observation.

2. Other fish are abundant here, but have diminished in numbers within the past twenty years, and I desire to respectfully call your attention to the probable cause. It is a well-known fact that brook trout will not remain in creeks below lumber-mills if the sawdust is thrown into them, for the sawdust, it is supposed, gets into their gills. The same reason would account for fish of all kinds being less plentiful now along the coast of Georgia than heretofore, as there is an immense amount of lumber sawed; and in most cases the sawdust is put in the water.

17. In November, north of Hatteras, in a body.

18. Supposed to go east to the Gulf Stream.

19. Possibly along the edge of the Gulf Stream.

20. Probably animalculæ, as their mouth seems formed for straining water.

34. For other fish, cast-nets are used.

35. Length, 6 feet; spread, 12 feet.

I beg to be allowed to add that a species of shell-fish called *prawn* (or shrimp of large growth) is very abundant on this coast during the months of March, April, and May. The length of body, after the outside shell is taken off, is from 4 to 6 inches. They are considered a great delicacy, and may be canned by a very simple process and made an article of commerce.

There is also a small fish found here in great abundance at all seasons of the year, called *finger-mullet*, a very sweet fish. There is reason to believe that this fish would rival the sardine if canned in the same or a similar manner. Its length is from 5 to 6 inches.

SAINT MARY'S, GA., *January* 28, 1875.

SIR: I have the honor to acknowledge the receipt of your circular of the 23d ultimo, relative to statistics of fisheries, and to reply that since my last communication I have learned from one of the Saint Andrew's, Ga., bar pilots that schools of fish called menhaden come into that sound with the flood-tide and go out with the ebb from the month of April until October, but not in as great numbers as found at the North. The same fish are also seen in calm weather during the winter months outside the sea islands in about seven fathoms of water in large schools from 3 to 4 feet below the surface. My informant says he has caught them at such times with snatch-hooks.

Very respectfully,

JOSEPH SHEPARD.

Hon. SPENCER F. BAIRD,

Commissioner of Fish and Fisheries, Washington, D. C

76. *Statement of J. F. Hall, Brunswick, Ga., April* 11, 1876.

First. They do not frequent the coast in this latitude.

Second. There have been a few schools seen off this coast. One was in Saint Andrew's Sound, latitude 31° 3′, in the spring of 1871. I saw one myself on May 30, 1872, latitude 31° 15′, in about eight fathoms of water. One school was reported off the coast by pilots in the summer of 1874.

---

77. *Statement of Capt. David Kemps, New Berlin, Fla., February* 10, 1875.

1. Bony fish.
2. Greater.
3. Increased very much.
6. Come in the river about December in large schools about the full of the moon; more numerous at that time than any other, and continue until May.
7. Swim high and low at times, and make a ripple and attract sea-gulls.
8. Not known. No one has made it a study.
9. Regular, and seem to increase both in size and number.
11. More numerous on the flow of the tide.
12. Near the mouth of the river.
13. All depths; they have been caught as low as 17 feet.
14. Not in the least.
16. The young fish leave the river from July to October, and then in solid bodies mix with young shad.
19. In the river, within 30 miles of its mouth.
20. Supposed to live on small animal-matter in the water.
21. They certainly spawn within the limit of 30 miles from the bar, as they are never seen higher up. They are supposed to spawn in the creeks and coves of the river, as they are alive with the young in the summer and fall of the year.
22. They are mixed indiscriminately
23. Has never been noticed.
24. No particular temperature.
28. Yes; in the creeks and coves of the river.
29 Yes; late in the season, say about April.
30. Catfish, garfish, crabs, eels, trout, and other fish.
31. At times we find a few fish with fish-lice in their mouth.
32. Sharks, jew-fish, porpoise, bass, and catfish are their greatest enemies, to both old and young, and they destroy a great many.
33. Yes; about four years ago they died in great numbers and were washed upon the shore of the river.
34. No particular nets are used. What are caught are in shad-nets having a 5-inch mesh. They are about 17 feet deep and all lengths.

There are about fifty nets on the river. I suppose during the season they will catch about five hundred bushels. They are a nuisance to the shad fishermen.

36. None employed.

39. Yes, more, in shad-nets, on flood-tide toward high water.

40. More numerous with northeast wind.

41. None.

42. What few are caught are used for manure.

43. None.

I will here state that these fish have steadily increased in size and numbers for the past five years. They are supposed to be much more plentiful on the coast outside of the bar.

---

78. *Statement of Charles Koch, Jacksonville, Fla., January* 15, 1874.

1. Yellow-tail.

2. In the waters of the Saint Mary's, Amelia, Bell River, and Cumberland Sound in greater numbers than other fish.

3. Increased.

5. No.

6. In February the yellow-tail appear in large schools.

7. They swim high in water only about 2 or 3 feet deep, and are only known by their capture and by the movements of sea-birds.

8. From the Atlantic Ocean, and they return by the ebb to the ocean.

9. Regular.

10. No nets are used; they are caught by hundreds with hook and line.

11. They come with the tide, and return to the ocean with the ebb.

12. Oysterbanks and sandy ground, in clear water.

13. From 3 to 5 feet; as much as 12 feet from the surface.

14. In water from 60 degrees and upward the fish are more solid and fat.

15. Appear on the breeding-grounds in companies, and are of every size and age.

16. Young fish are seen and caught from 4 to 9 inches long.

17. Leave the coast in September by degrees.

20. Small shrimp, sandbäre, and barnacles.

21. In the small creeks from March to the end of April.

22. I find that these fish go in pairs.

23. Yes.

24. Sixty to 75 degrees.

25. One to 2 feet near the bottom.

26. The eggs sink to the bottom, and become attached to oysterbeds, stones, grass, &c.

28. The young fish are found in abundance in the small creeks.

29. Yes.

30. Wild ducks, crabs, and barnacles destroy spawn and young fish.

31. Worms and lampreys are often found attached to the outside and on the gills; in few cases in the mouth.

32. Sharks and salt-water catfish attack these fish.

33. No.

34. They have been captured in nets by accident, but the fishermen here only fish for finer kinds of fish.

35. Nets for catching other fish are from 100 to 200 yards long and 10 feet deep.

36. None.

39. Yes; on the morning tide.

40. Yes; north and west wind have effect on them.

42. These fish are used as bait and as food for hogs and chickens, or as manure.

43. None.

---

79. *Statement of D. P. Kane, Matagorda, Tex., March* 1, 1874.

Capt. William Nichols, a pilot residing at Saluria, Tex., informs me that in September, 1872, great quantities of pogies drifted upon the beach at Saluria, and that the waters of the Gulf of Mexico and Matagorda Bay were full of them; he did not observe whether they were fat or not.

I have been engaged in pogy fishing in Maine for eight years; have fished from Florida to Mexico, but have never seen or heard of menhaden ever being south of Cape Hatteras, with the above exception.

APPENDIX O.

MISCELLANOUS ITEMS REGARDING THE USE OF FISH FOR MANURE.

1. *The earliest printed account of the use of menhaden for a fertilizer, being an extract from an article by Ezra L'Hommedieu*, 1801.

Experiments made by using the fish called menhaden, or mossbunkers, as a manure have succeeded beyond expectation, and will likely become a source of wealth to farmers living on such parts of the sea-coasts where they can be taken with ease and in great abundance. These fish abound with oil and blood more than any other kind of their size. They are not used for food, except by negroes, in the English West India Islands; and the price is so low that it will not answer to cure them for market. They are easily taken in the month of June, when they come near the shores in large and numerous schools. These fish have been used as a manure in divers ways and on different soils.

1st. In dunging corn in the holes, put two in a hill in any kind of soil where corn will grow, and you will have a good crop. The Indians on the sea-coasts used to dung their corn with wilks and other shell-fish, and with fish if they could get it.

2d. By spreading those fish on the ground for grass a good crop is produced; put them on a piece of poor loamy land, at the distance of 15 inches from each other on the turf, exposed to the sun and air, and by their putrefaction they so enrich the land that you may mow about two tons per acre. How long this manure will last experience has not yet determined.

3d. An experiment was made the last summer by one of my near neighbors, Mr. Jonathan Tuthill, in raising vegetables with this fish-manure. About the first of June he carted near half an ox-cart load of those fish on 20 feet square of poor light land, being loam mixed with sand. The fish he spread as equally as he could by throwing them out of the cart. Being exposed to the weather they were soon consumed. He then raked off the bones to prevent their hurting the feet of the children who might go into the garden, and plowed up the piece and planted it with cucumbers and a few cabbages. The season was extremely dry, and but very few cucumbers were raised in the neighborhood except what grew on this small piece of ground, and here the production exceeded anything that had been known. By his own computation, and that of his neighbors, this 20 feet square of ground produced more than forty bushels of cucumbers, besides some fine cabbages. I measured the ground myself, and make no doubt of the quantity adjudged to have grown on the same.

By putting these fish on the land for manure, exposed to the air until they are consumed, there can be no doubt that a considerable part of the manure is lost by the effluvia which passes off the putrefied substance, as is evident from the next experiment.

4th. Mr. Joseph Glover, a farmer in Suffolk County, having a small poor farm, for a few years past has gone into the practice of making manure with these fish for the purpose of enriching his land, which is a loamy soil, dry, and in parts light. He first carts earth and makes a bed of such circumference as will admit of being nine inches thick; he then puts on one load of fish, then covers this load with four loads of common earth; but if he can get rich dirt he then covers it with six loads, and in that manner makes of fish and earth a heap of about thirty loads. The whole mass soon becomes impregnated and turns black. By experience he finds that fifteen ox-cart loads of this manure is a sufficient dressing for one acre of his poor land, which produces him thirty bushels of the best wheat by the acre, and the next year from the same land sown with clover-seed he has cut four tons of hay, which he computes at two loads and a half by the acre. The expense of making this manure where the fish are plenty cannot exceed three shillings per ton, and is the cheapest manure, considering its quality, of any yet known,

provided it is durable, which cannot yet be determined. On some parts of Long Island those fish are taken in seines, and carted six and seven miles for the purpose of manure, and is found to be very profitable business.

Mr. Glover relates a circumstance which is curious, and confirms some experiments made by Dr. Priestly, and at the same time shows that you derive less benefit from those fish when exposed to the air than when covered with earth. He made a heap composed of those fish and earth in the manner above related, near a fence where a field of wheat was growing on the opposite side. The wheat near the heap soon changed its color and grew luxuriant; and at harvest yielded nearly double the quantity of the other part of the field. He is confident that the wheat could derive no nourishment from the heap or compost by its being washed by rains to the ground on the other side of the fence where the wheat grew, and could be affected only by the effluvia arising from the putrefaction of the fish and absorbed by the leaves of the wheat.*

---

2. *Letters from Prof. C. A. Goessmann, on the agricultural value of menhaden fertilizers.*

AMHERST, MASS., *October* 6, 1877.

DEAR SIR: In answer to your favor of the 2d inst., requesting me to state whether my views regarding the character and the agricultural value of the menhaden fish-fertilizers are fully expressed in my official reports, I take pleasure to reply that my third annual report, which is published in the twenty-third annual report of the secretary of the Massachusetts State Board of Agriculture (1875 to 1876), contains the most detailed exposition of my opinions regarding that subject. Well-prepared fish-refuse from our menhaden fish-rendering works are justly considered equal to the best branch of our home manufactured nitrogenous phosphates in commercial and agricultural value. Fish-fertilizers repair to some extent the injury which agriculture suffers from the customary wasteful sewage system of our large cities; to secure an increased supply is worthy of the most careful consideration from an economical stand-point. The due appreciation of our fish-fertilizers suffers still from their variable composition; they differ quite frequently largely in moisture, and are, as a general rule, too coarse to secure speedy action. A more uniform mode of rendering and a more satisfactory mode of drying and grinding are very desirable for obvious reasons. To separate the rendering business from the manufacture of the fertilizers promises better chances for the removal of the present difficulties. I am informed that a patent has been secured to abstract the fat more thoroughly by some chemical process—I presume by means of bisulphide of

* Communications made to the society, relative to manures, by Ezra L'Hommedieu, esq. < Transactions of the Society for the Promotion of Agriculture, Arts, and Manufactures, instituted in the State of New York. Vol. I, 1801, pp. 65–67.

carbon or benzine—yet I cannot vouch for the correctness of that statement; to render but slightly the fish mass and to abstract the remainder of the fat subsequently with some suitable liquid, benzine, &c., would be a step in the right direction. I found 18 per cent. of fat in dried fish-scraps; a good Norwegian fish-guano contains frequently but from 2.5 to 3 per cent. of fat, and is ground to a fine powder. The entire removal of the fat favors the drying of the fish mass and increases its percentage of nitrogen and phosphoric acid, which in turn raises the commercial value of the resulting material. The feeding of the fish-guano as a rich article of food to our domesticated herbivorous animals, as sheep, &c., has engaged of later years considerable attention on the part of scientific investigators as a more economical mode of using fish for fertilizing purposes. The German experiment stations at Proskau and at Hohenheim have published of late interesting confirmatory results. I take the liberty to inclose a page of printed matter, which contains a fair statement of present values of fertilizing substances; it is taken out of my fourth annual report on "commercial fertilizers," and may prove of interest to you. Offering my services most cheerfully in case my opinion on any particular point should be desirable, I remain

Very respectfully, yours,

C. A. GOESSMANN.

Prof. G. BROWN GOODE,
Washington, D. C.

AMHERST, MASS., *November* 24, 1877.

DEAR SIR: I sent to day by mail such of my reports as are still on hand. I regret that I have no copy of my third report, which contains the most detailed discussion on fish and fish fertilizers. I presume by writing to Hon. Charles L. Flint, secretary of the Massachusetts State Board of Agriculture, Boston, for his annual report of 1875 to 1876, which contains my third report, you may be able to secure a copy. A carefully dried and finely ground fish is considered to be one of our best substitutes for the Peruvian guano, which is formed from the excretions of fish-eating animals, as sea-birds, &c. To secure a similar speedy influence on the growth of plants, it is customary to compost fish with soil in the usual manner a month or two previous to the designed use. The flesh of fish coming from the rendering vats is in an excellent condition for rapid disintegration; the same may be said regarding the fish-bones. An addition of sulphuric acid to fresh fish-refuse from the oil-press exerts a beneficial influence on the gradual disintegration of the organic matter and the bones, securing at the same time the entire amount of nitrogen by rendering the ammonia formed non-volatile. Larger quantities of sulphuric acid produce an increased amount of soluble phosphoric acid. A good fish-guano belongs to our richest nitrogenous materials for manuring purposes. An addition of soluble phosphates in many in-

stances aids in economizing its nitrogen, and thereby lessens the expenses for the production of many of our farm crops. Potash compounds added to fish-guano tend to produce a more complete fertilizer, and therefore renders its use safer wherever larger proportions of potash compounds are essential for the crops under cultivation. Fish-guano, like Peruvian guano, is very deficient in potassa. To render the fish before working them into fertilizers is not only good economy as far as the gain of the oil is concerned, it favors also a more rapid disintegration of the organic matter by allowing the moisture freely to permeate the entire mass. The more the fat has been removed previous to their incoporation into the soil, the more speedy will be their disintegration and subsequent diffusion in the soil. Oil appears also to be indifferent to plant-growth.

Wishing that these short discussions of your special inquiries may be not without interest to you, I remain

Respectfully, yours,

C. A. GOESSMANN.

Prof. G. B. GOODE,
Middletown, Conn.

---

3. *A Description of the factory of the Pacific Guano Company, at Wood's Holl, Mass.*

Menhaden scrap is used to a considerable extent for the purpose of securing the desired proportion of nitrogen (ammonia) in the manufacture of those commercial fertilizers known as superphosphates. By many manufacturers it is used only incidentally, their chief reliance being bird-guano or the dried refuse of the slaughter-houses. The Pacific Guano Company of Boston, however, make it their base for ammonia, and use it as a principal ingredient of their manufactured guano. This company was established in 1861 by a number of ship-owners in search of business for their unemployed vessels. Having purchased Howland's Island in the Southern Pacific, where there was a rich deposit of bird-guano, they established their business on Spectacle Island, in Boston Harbor, and here they carried their guano, and, having dried it in the vats of the deserted salt-works, put it up in bags for the market. After a time it was suggested that the guano might be improved by the admixture of refuse fish, and that the ammonia lost by exposure to the weather might thus be replaced. In this way the use of menhaden chum, already well known as a manure, was introduced into the manufacture.

In 1863 the works were removed to Wood's Holl, Barnstable County, Massachusetts, with the intention of capturing the fish needed, and after extracting the oil, applying the pumice to the manufacture of guano.

To this end an extensive outfit of vessels and nets was obtained and a force of men employed. The location, however, proved to be unfavorable, and after five years' trial the fishery project was abandoned. At this point, however, there was little difficulty in procuring the necessary supply of fish-scrap from the oil-works on Narragansett Bay and Long Island Sound.

About 1866 the supply of guano on Howland's Island having become nearly exhausted, its place was gradually supplied by the phosphate of lime brought from Swan Island, and two years later by the South Carolina phosphates.

The use of the bird-guano, from which the company originally took its name, has been entirely discontinued, though for some years it was the custom to add a small percentage of that substance. The mineral phosphates are found to supply its place very satisfactorily.

The company has two factories: that at Wood's Holl and another near Charleston, S. C. The capacity of the latter is about two-thirds of the former, although the working force is about the same. That at Wood's Hole, which may be considered a representative establishment, is situated on Long Neck, about half a mile northwest of the village. The factory buildings are very extensive, covering nearly two acres of land, and are used exclusively in the manufacture of the guano, and sulphuric acid used in its development, and for storing the raw materials.

A gang of about 85 men is employed, one-third of whom are engaged in loading and unloading wharf-work, one-third in manufacture, and one-third in packing for shipment. At one time as many as 125 men were employed, but the introduction of labor-saving machinery has rendered a considerable reduction of the force practicable, while at the same time the working capacity of the factory has been largely increased.

A steam-engine of 120 horse-power is used; also two small hoisting-engines for loading and discharging cargoes. The ingredients of manufacture are few and simple, viz: fish-scrap, mineral phosphate of lime, sulphuric acid, and incidentally kainit, and sometimes common salt.

The average annual purchase of scrap amounts to not far from 10,000 tons. It is stored in bulk in great wooden sheds, and is sometimes retained a long time before it can be used. At the time of writing, August 16, 1875, a large quantity remains over from the previous year. The store-houses cover an area of 16,640 square feet, and the scrap is stowed to the depth of 15 feet, giving a storage space of 159,600 cubic feet.*

The mineral phosphate is obtained chiefly from South Carolina, from

* In a letter of October 8, 1877, Mr. A. F. Crowell states: "In our business here we consumed for the year 1875–'76, 708 tons dry scrap (menhaden), value $20,164; 2,338 tons crude scrap, value $31,682; producing 13,010 tons soluble Pacific guano; 1876–'77, 2,176 tons dry scrap, value $57,784; 5,188 tons crude scrap, value $52,248; producing 11,398 tons soluble Pacific guano. Our works at Charleston usually consume one-third less than here."

the Ashley and Cooper Rivers and from Chisholm's Island in Bull River, near Saint Helena Sound. The company owns Swan Island, situated in the Caribbean Sea, about 290 miles off Jamaica, and the phosphate of lime was obtained from that point until 1866 or 1867, when the reopening of the south gave access to the Charleston beds. The company of late has used a considerable quantity of the rock from Navassa, a small island lying between Cuba and Santo Domingo, a reddish deposit, rich in phosphate of lime. This deposit is estimated to contain on the average 72 per cent. of phosphate of lime, while the brown deposit from Saint Helena Sound, technically known as "marsh-rock," contains 60 per cent., and the yellow "land-rock," from the vicinity of Charleston, only 50. About 12,000 tons of this rock is used annually in the Woods Holl establishment. Great piles of rock are to be seen lying out of doors and under sheds, and at the time of my visit it was estimated that there were seven or eight hundred tons on hand. The only damage to which it is liable from exposure is that it collects moisture and becomes more difficult to grind. In such cases it is piled in great heaps upon a brick floor, and roughly kiln-dried by a fire of soft coal kindled under it.

The sulphuric acid used is manufactured on the spot from Sicily sulphur, which is brought in vessels from Boston and direct from the Mediterranean. About 1,200 tons of sulphur are used annually, and not far from 3,000 tons of sulphuric acid. The sulphuric acid used in manufacture is brought up to a standard density indicated by 66 on the Baumé hydrometer, a specific gravity of 1.7674.

The buildings used in this branch of the business are nearly as extensive as all the others. The three leaden tanks have a capacity of 185,000 cubic feet, the smaller containing 48,000 the others 2,000 and 6,500 respectively.

In the early days of the business the sulphuric acid was brought from Waltham, Mass., and New Haven, Conn., in carboys, but since 1866 it has been manufactured in Woods Holl at a large saving of expense. The Leopoldshall kainit, which averages about 12½ per cent. potash, comes from the mines at Leopoldshall, in the Duchy of Anhalt, near Stassfurt, in Germany. Its use is comparatively recent, until this year it having been impracticable to obtain it in any considerable quantity. At the time of my visit a Hamburg brig was discharging a cargo at the wharf. Not far from 500 tons are used annually. It takes the place of the coarse salt formerly used, a refuse product from the gunpowder works at New Haven, Conn.

The process of manufacture is sufficiently simple. The fish-scrap, on its reception, is stored, after being mixed with about 3 per cent. of its weight of kainite. This is a precaution necessary to prevent fermentation and putrefaction. Experiments are now in progress to test the effect of a large mixture of kainite, which it is hoped will do away entirely with this trouble. Common salt, as has been stated, was formerly used for this purpose.

The phosphate, as needed, is crushed in a stone-crushing machine, and ground between millstones to the consistency of fine flour. A convenient arrangement of hoppers and elevators greatly facilitates this part of the work.

The scrap having been stored in one wing of the factory, the ground phosphate in another, the sulphuric acid having been forced into a reservoir near by, by pneumatic pressure, the process of mixing is easily carried on. For this work, two of Poole & Hunt's patent mixers are employed. These are larger basins of iron, each of which contains about a ton of the mixed material. In these the ingredients are placed in the proportion of 1,000 pounds of phosphate, 900 of scrap, and from 300 to 450 pounds of sulphuric acid. The basins then revolve rapidly, while a series of plows on one side, also revolving, thoroughly stir the mass which passes under them. Fifteen minutes suffices for a thorough mixture, and the guano is removed to a storage-shed, where it remains for six weeks or more to allow the ingredients to thoroughly combine. It is then thrown into hoppers, passed through rapidly-revolving wire screens, and after it has been packed in 200-pound sacks is ready for the market. About 600 bags can be filled in a day.

Before the invention of the Poole & Hunt mixing machine the guano was mixed with hoes in large wooden or stone tubs. This process was laborious and very expensive, and various machines were devised, but they proved failures because the materials caked, clogging the wheels and knives in a very short time.

The guano often contains hard lumps such as cannot be pulverized by the wire screen. Residue of this kind is subjected to the action of the Carr disintegrator, which consists of two wheels revolving in opposite directions at the rate of 600 revolutions to the minute.*

The offensive odor of the factories renders them disagreeable to persons residing in the neighborhood, and legal measures have been taken in one or two instances to prevent the manufacturers from carrying on their business, May 5, 1871, at the session of the United States circuit court in New Haven, Judge Woodruff, Connecticut *vs.* Enoch Coe, of Brooklyn, N. Y., granting an injunction to restrain the defendant from manufacturing manure from fish at his works in Norwalk Harbor, on the ground that the same created a nuisance. In 1872 the Shelter Island Camp-meeting Association made an effort to have the factories on Shelter Island closed, on the same grounds. People interested in building up Woods Holl as a watering place once agitated legal measures to compel a removal of the works, but the general sentiment of the town of Falmouth, in which the company pays heavy taxes, and specially of the many villagers of Woods Holl who earn their living in the works, prevented any results.

---

* The above description was written up in 1874 from facts contributed by Messrs. Crowell and Shiverick, of the Pacific Guano Company, and short-hand notes taken by Mr. H. A. Gill.—G. B. G.

4. *The Cumberland Bone Company's works.*

The following account of a similar establishment in Maine is taken bodily from the report of Boardman & Atkins. The facts appear to have been compiled from an article in the Lewiston Evening Journal, for August 17, 1874.

"The Cumberland Bone Company, whose works are located in Booth Bay, is more largely engaged in the use of fish-scrap in the manufacture of commercial fertilizers than any other company operating in this State. The works of this company, formerly located in Cumberland County, were removed to Booth Bay in 1873–'74, and altogether occupy six buildings for the various purposes connected with their business. They use South Carolina phosphatic rock, Nevassa, ground bones, fish, scrap, sulphuric acid, salt cake, and a slight amount of deodorizing compound. The phosphatic rock is heavy and solid, of a grayish color, in lumps of all sizes, and is bought by the cargo. The Nevassa is reddish brown in color, quite fine, a little lumpy, but not at all solid, and is a sort of guano from an island of the same name in the West Indies. These two are ground together in the proportion of two parts of the former to one of the latter; being ground to a fine powder which is of a grayish cinnamon-brown color. The fish-scrap used by the company is furnished by the Atlantic Oil Works, whose establishment is situated very near the works of the former company. Before being used it is treated with the deodorizing mixture—a substance of a very faint yellow color, of which, judging from its appearance, one would say that gypsum might be the foundation. This mixture is made in one of the buildings of the company provided with a furnace and the necessary tanks or retorts, and its preparation is a secret process, understood to have been invented by the president of the company. It is said to have been thoroughly tested and to work well, and it is thought will come into use generally among the companies that handle fish-scrap. At present a good many of them are troubled with injunctions because of the stench arising from the accumulated scrap, which is constantly giving off its ammonia. After being treated with this deodorizer the scrap is placed in barrels, and is quite inoffensive, a slight odor of ammonia being observable. Bones are ground raw; to get them fine enough they go through several mills, but they are not reduced near so fine as the phosphatic rock or Nevassa. The company sell large quantities of this bone meal as feed. One of the buildings of the company is used for the manufacture of sulphuric acid, of which sulphur and niter are the principal ingredients. Salt cake is a residue from the distillation of niter as carried on in the acid works. The mixing of the ingredients into superphosphate is performed in the mixing-room, an apartment of the main manufacturing building. Over a circular floor, about eight feet in diameter, revolve horizontally several arms with breaks and scoops attached. Ingredients are poured upon the floor, the arms revolve, dense fumes

arise from the chemical action, and in a very short space of time the process is complete. The arms stir the mixture together perfectly and collect it in the middle of the table, whence it is dumped into the basement. Here it is piled up, and as soon as convenient it is passed through a long cylinder, where it is dried by hot air. It is then passed through a long series of revolving sieves, and all the coarser particles, which consist altogether of pieces of fish, are dried and ground over again. The superphosphate is then barreled. It is a very dark gray, almost black in some specimens, but drying off to a light gray. In some lots there is a brownish tinge. In mechanical texture the superphosphate in the barrels is not perfectly fine—a great quantity of bits of fish remaining unchanged in it. The proportion of the different ingredients used in the manufacture of superphosphate at these works cannot be stated, and is probably one of the secrets of the business. A gentleman who has furnished much information for this paper says that "one ton of fish scrap furnished the ammonia for three tons of superphosphate; the larger portion of the other ingredients being Nevassa, which costs about $14 per ton, and gypsum, which costs 75 cents per ton." The capital stock of this company is $200,000, and it gives employment to about fifty men. It made in 1874, 10,000 tons of commercial fertilizer, valued at $450,000. The works are regarded as the most complete of the kind in the country, are provided with a seventy-five-horse-power engine, and with extensive fixtures for the manufacture of sulphuric acid, which when in operation will make six tons of acid per day. The entire cost of the buildings and machinery was $110,000. It is obvious that these works were located here with good reason. One sees a car moved by steam ascending from the pogy-oil factory loaded with chum. It passes upon scales, is weighed and then moves on over an immense bin into which it is dumped. A chemical mixture is added to the heap to prevent the escape of ammonia and to kill the offensive effluvia."—[Boardman & Atkins, *op. cit.*, pp. 38-40.

5. *The Quinnipiac Fertilizer Company's Works.*

The Quinnipiac Fertilizer Company of New Haven was established in 1852, by William D. Hall, of Wallingford, Conn.; and is the oldest establishment of its kind in the United States. It was founded under Mr. Hall's patent for drying fish scrap by solar heat. Scrap was purchased from the oil manufacturers of Maine and Long Island, and, having been prepared for agricultural purposes, was sold to the Connecticut farmers for thirty cents a bushel. This fertilizer was not essentially different from that now sold by the same company as "dry-ground scrap." In 1854 the manufactory was removed from Wallingford to the banks of the Poquannock River, in Groton, and the company began buying fish and making oil. In 1857 it was again removed to Pine Island, where

the buildings now occupied by the company were put up. From that time their business has steadily increased. In 1871 the company began, in connection with their other enterprises, the manufacture of superphosphates; this was done for the purpose of using the fish scrap immediately after the oil had been expressed, thus avoiding that loss of ammonia which takes place when the pomace is allowed to ferment. They still continue the process of solar drying on platforms, finding that it is more profitable to prepare in large quantities in this manner, at the same time using what is necessary in the manufacture of superphosphates. They have tried several machines for artificial drying, but have not found any which are sufficiently capacious to be profitably employed.

In the manufacture of their superphosphate they use dried and fresh fish-scrap, Nevassa phosphates, pulverized bone, kainit, and sulphuric acid.

They produce annually about 2,000 tons of superphosphates and 3,000 to 4,000 tons of other fertilizers, which are widely distributed through the New England and Southern States, and are also sent to the West Indies, Santa Cruz, Porto Rico, Cuba, and the Bermudas.

Their manufactured products are classed by four grades: (1) Pine Island Superphosphate, containing from 4 to 5 per cent. of ammonia, 7 to 9 per cent. of phosphoric acid (average), and 2 per cent. of potash; (2) Pine Island Guano, containing 7 per cent. of ammonia and 7 of phosphoric acid, which is intended chiefly for tobacco farmers and market-gardners; (3) Quinnipiac dry-ground fish guano, which is sun-dried scrap thoroughly ground; and (4) crude or half-dried scrap.*

---

6. *The Crowell Chemical Manufacturing Company.*

A NEW INDUSTRY.—The Crowell Chemical Manufacturing Company, at Woods Holl, are now building a large factory that is nearly completed for the purpose of making fish flour for the European markets, this flour being a dry, inodorous poudrette for agricultural purposes.

As soon as the building is completed a large amount of machinery that is ready for the purpose will be placed in order immediately, and then the company will be ready to commence operations.

They will require twenty tons of fish each day to supply their needs, and as the whole fish is utilized by their process they desire large ones for their business, the bodies being valued in the following order: Black-fish, porpoises, sharks, dog-fish, porgies, and skates, the fish being bought entirely by weight.

Sharks will be purchased at about the same rates as porgies, as will dog-fish. The company will employ from one to three steamers to con-

* These facts were given us by Mr. H. L. Dudley, president of the company, during a visit to Pine Island in October, 1877.—G. B. G.

stantly cruise for their supplies, making trips from Block Island to the coast of Maine, touching at Noman's Land, Martha's Vineyard, Nantucket, Cape Cod, and other intermediate points, to see the fishermen and purchase their catches.

Dr. Sims, the head of this business, was the medical director of the Third Army Corps at the close of the rebellion, to which he was appointed after serving a year as surgeon on the staff of General Hooker, and is a gentleman of great business capacity and superior intelligence.—[Island Review.

"PACIFIC GUANO COMPANY,
"*Woods Holl, Mass., October* 8, 1877.

"DEAR SIR: Yours 2d at hand. An improved process for the treatment of fish is now being tested by myself and others. Experiments reveal to us that the fish can be preserved, and that we are able to get a scrap from them of higher grade in ammonia and a dry powder. The fish are treated with bisulphide of carbon and of hydrocarbons as benzine. The process removes all the oil and leaves the product in a dry powder. The by-product of oil is about eighty per cent. more than by kettle and press, and goes far towards paying expenses.

"The dry scrap as now obtained from menhaden yields on an average, 10.50 per cent. ammonia (NH_3); by the new process 14 per cent. ammonia (NH_3).

"We are erecting a building 85 by 40 feet, 34 feet high, to fully test the process, and expect to be in working order in December. I inclose an article taken from the Nantucket paper. You can no doubt give us valuable information in regard to the habits of the shark, their breeding-ground, &c. The fishermen represent a supply off Nantucket that can be taken with hook and line.

"In our business here we consumed for the year 1875–'76 708 tons dry scrap (menhaden), value $20,164; 2,338 tons crude scrap, value $31,682; producing 13,010 tons soluble Pacific guano; 1876–'77, 2,176 tons dry scrap, value $57,784; 5,188 tons crude scrap, value $62,248; producing 11,398 tons soluble Pacific guano. Our works at Charleston usually consume one-third less than here.

"The menhaden scrap is now dried more extensively than ever. The solar heat and hard platforms found to be the cheapest and most satisfactory process. We purchase what dry scrap we can in place of crude scrap. I send you the only document published bearing on the history of this company.

"Yours, truly,

"A. F. CROWELL.

"Prof. G. BROWN GOODE."

7. *Methods of calculating costs of valuable ingredients of fertilizers.**

The method referred to on page 235 consists in comparing different fertilizers by the costs per pound of the valuable ingredients at the prices at which the articles are sold.

The way in which these computations are made here may be explained as follows:

Take first a simple case, a sulphate of ammonia containing 20 per cent. of nitrogen, and sold at $100 per ton. Twenty per cent. is equivalent to 400 pounds in a ton of 2,000 pounds. These 400 pounds of nitrogen cost $100. One pound will therefore cost $\$100 \div 400 = 25$ cents.

Now, a more complicated case. Suppose a superphosphate to contain valuable ingredients (and that, for convenience, we indicate the latter by abbreviations), as below:

Soluble phosphoric acid, (Sol.).......	10 per cent.=200	pounds	in	ton,
Insoluble phosphoric acid (Ins.)	2.5 per cent.= 50	"	"	"
Nitrogen (N.)	3 per cent.= 60	"	"	"

that it be sold at $40 per ton, and that the values of the ingredients are in the ratios of Sol. 15, Ins. 6, and N. 25 cents per pound. The problem will be to find a series of values in the ratios 15 : 6 : 25, which, multiplied by the respective numbers of pounds of Sol., Ins., and N. in a ton, will give three products, whose sum will be $40. The method employed here for solving the problem is as follows: The assumed rate for Ins. was 6 cents, that for Sol., 15 cents, or $2\frac{1}{2}$ times as much, and that for N. 25 cents, or $4\frac{1}{6}$ times as much. Multiply the number of pounds of Sol. in a ton by $2\frac{1}{2}$, and that of N. by $4\frac{1}{6}$, and add the products to the number of pounds of Ins., and the sum will be the number of pounds of Ins. which would have the same value as the Sol., Ins., and N. actually present taken together. Divide the whole cost by this sum and the quotient will be the cost of one pound of Ins. This multiplied by $2\frac{1}{2}$ will give the cost of one pound of Sol., and by $4\frac{1}{6}$ will give the cost of one pound of N. The calculations for the above case will be:

Sol.............................	200 pounds	$\times 2\frac{1}{2}$=500	pounds	Ins.
Ins	50 "	$\times 1$ = 50	"	"
N.	60 "	$\times 4\frac{1}{6}$=250	"	"
		800	"	"

The price per ton, $40, divided by 800, gives 5 cents, the cost of one pound of Ins.; $5 \times 2\frac{1}{4} = 12\frac{1}{2}$ cents cost, of one pound of Sol.; and $5 \times 4\frac{1}{6} = 20\frac{5}{6}$, cost of one pound of N.

*From report of Connecticut Agricultural Experiment Station, 1876, W. O. Atwater, director.

The proof of the correctness of these figures is plain:

Soluble phos. acid,	200 lbs., @ $12\frac{1}{2}$ cents, would cost	....	\$25 00
Insoluble " "	50 lbs., @ 5 " " "	....	2 50
Nitrogen†	60 lbs., @ $20\frac{5}{6}$ " " "	....	12 50
Total valuable ingredients in ton would cost		....	\$40 00

Another method for calculating the costs of ingredients, which consists in estimating the value of one at an assumed rate per pound, subtracting its total value, as thus computed, from the whole cost, and dividing the remainder by the number of pounds of the other ingredients to get the cost of the latter, is too simple to require further explanation here.

In valuations current in this country, nitrogen in these substances has been reckoned as worth all the way from two to five times as much as phosphoric acid, pound for pound. Considering the fact that the nitrogen is generally in quite readily, and the phosphoric acid often in very slowly available forms, there is ground for varying ratios. A full discussion of this subject would require more space than either the knowledge at our disposal or the necessary limits of this article would permit. In brief, however, I do not find it easy to see why, if nitrogen is worth only about twice as much as phosphoric acid, pound for pound, when both are in their most available forms, it should be worth three or four times as much, as is sometimes assumed, in bone, in which both occur in much less available forms. Too little is known at present of the effect of decomposing nitrogenous matter in bone, fish, castor-pomace, and the like, in dissolving, diffusing, and otherwise rendering available the phosphates with which it is so intimately connected, to enable us to form any accurate estimate of its value on this account. I confess that in the light of the little knowledge that we do have it seems to me more just to preserve ratios of valuation of nitrogen and phosphoric acid in bone the same, or nearly the same, as in the most available forms. In fish, animal refuse, and other materials which contain considerable nitrogenous matter other than that so intimately mingled with the phosphate, and in a form probably more ready to decompose, it seems reasonable to give the higher relative value to nitrogen.

In view of such considerations as these, the costs of nitrogen and phosphoric acid in the tables in this report have been calculated on the basis of ratios as follows:

In fish, slaughter-house refuse, and castor-pomace—Nitrogen : Phosphoric acid :: $2\frac{1}{2}$: 1.

In bone—Nitrogen : Phosphoric acid :: 2 : 1.

In superphosphates the costs of the ingredients are calculated on a basis of ratios as per the valuations used in the last report of the station, to wit: Nitrogen, 25; phosphoric acid, soluble in water, 15; soluble in ammonium citrate, 10; insoluble, 6.

In Peruvian guanos the same rates are adopted as for the superphosphates, the additional ingredient potash being rated at 8.

The prices are those at which the articles have been sold, or offered to farmers during the year at the places of sale; the lower rates in large quantities, lots of a ton or more, for cash; the higher one for smaller lots, or on time.

In addition to the analyses and valuations given in the text of the report, the following are presented as indications of the actual condition of the fertilizer market in respect to three most important classes of commercial fertilizers—nitrogenous superphosphates, Peruvian guanos, and fish manures. The prices given are those which prevailed in 1875–'76, and are in some cases a trifle higher than now rule.

TABLE I.

Nitrogenous phosphates and superphosphates.

Name of fertilizer.	Station number.	ANALYSES.									VALUATIONS.					
		Moisture.	Sand, &c.	Phosphoric acid.				Potash.	Nitrogen.	Ammonia equivalent in nitrogen.	Retail price per ton.	Cost of one pound each of valuable ingredients at prices stated.				
				Available.		Insoluble.	Total.					Nitrogen.	Phosphoric acid.			Potash.
				Soluble.	Reverted.								Soluble.	Reverted.	Insoluble.	
		Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.		Cents.	Cents.	Cents.	Cents.	Cents.
Dissolved Bone, Thompson & Edwards	14	9.02	3.77	1.31	......	11.43	12.74	......	3.65	4.44	$48 00	31.2	18.5	......	8.9	......
Do	25	8.71	......	None.	......	12.77	12.77	......	4.25	5.15	48 00	30.3	......	......	8.6	......
Do	107	12.37	......	None.	......	12.38	12.38	......	3.99	4.84	47 50	31.5	......	......	9.0	......
Dissolved Meat and Bone, Thompson & Edwards	165	13.51	......	None.	6.67	7.41	14.08	......	5.20	6.31	50 00	24.5	......	10.5	7.0	......
Ammoniated Bone Superphosphate, Thompson & Edwards	18	15.95	0.90	None.	......	8.31	8.31	......	3.40	4.12	48 00	41.5	......	......	11.9	......
Do	26	14.84	......	None.	......	13.78	13.78	......	4.16	5.05	48 00	29.6	......	......	8.4	......
Do	139	19.31	2.27	1.70	8.60	3.22	13.52	......	2.99	3.62	50 00	29.0	17.2	12.4	8.3	......
"Pure Bone"	81	7.54	......	......	......	15.22	15.22	......	5.46	6.62	45 00	22.9	......	......	6.5	......
Riverside Phosphate	30	20.16	......	......	......	20.44	20.44	......	4.18	5.07	45 00	22.4	......	......	6.4	......
Ammoniated Bone Superphosphate, G. W. Miles	11	19.37	2.60	9.91	0.16	0.80	10.87	......	2.75	3.33	48 00	26.8	15.9	11.4	7.7	......
Do	27	18.50	......	4.92	......	4.64	9.56	......	2.98	3.62	......	......	......	......	......	......
Do	79	24.15	3.40	9.28	2.61	0.91	12.80	......	2.57	3.12	45 00	23.7	14.1	10.1	6.8	......
Ammoniated Bone Superphosphate, Russell Coe	12	18.47	0.35	6.24	1.28	6.39	13.91	......	1.92	2.33	42 50	26.5	15.8	11.4	7.6	......
Do	135	20.16	......	12.05	0.34	0.57	12.96	......	2.94	3.56	40 00	19.2	11.4	8.2	5.5	......
Do	128	21.01	......	11.67	0.92	0.20	12.79	......	2.24	2.71	40 00	20.7	12.3	8.9	5.9	......
Do	168	19.35	......	12.53	0.46	......	12.99	......	2.04	2.47	45 00	23.2	13.8	9.9	......	......
Do	170	22.27	......	11.05	1.08	......	12.13	......	3.84	4.66	50 00	22.9	13.7	9.8	......	......
Ammoniated Bone Superphosphate, Preston & Sons	15	21.75	3.60	9.94	......	4.10	14.04	......	1.67	2.03	42 50	24.2	14.4	......	6.9	......
Do	134	24.97	......	7.86	1.32	1.78	10.96	......	2.87	3.48	40 00	23.1	13.8	9.9	6.6	......
Superphosphate, Bridgeport Sulphuric Acid Company	17	23.33	6.90	2.82	8.23	1.89	12.94	......	0.88	1.06	45 00	33.9	20.2	14.5	9.7	......
Do	56	9.37	8.41	3.67	......	7.43	11.10	......	1.14	1.38	......	......	......	......	......	......
Superphosphate, Lister Bros	95	19.09	......	10.29	2.12	1.38	13.79	......	2.65	3.21	45 00	22.3	13.3	9.5	6.4	......
Superphosphate, Lombard & Matthewson	122	4.29	4.78	5.75	6.38	2.89	15.02	......	2.92	3.54	50 00	25.2	15.0	10.8	7.2	......
Superphosphate, J. O. & E. Smith	63	12.35	1.45	5.06	......	12.84	17.90	......	2.83	3.43	......	......	......	......	......	......
Do	132	19.53	2.50	5.71	4.94	0.27	10.92	......	2.67	3.24	40 00	24.2	14.4	10.4	6.9	......
Superphosphate, Wilson's	133	19.70	2.62	5.84	1.19	1.04	8.07	......	2.39	2.90	40 00	29.9	17.8	12.8	8.6	......
Superphosphate, Stagg's	169	13.52	......	11.22	0.44	1.75	13.41	......	2.65	3.21	55 00	27.4	16.3	11.7	7.8	......
Phosphatic Blood Guano, Manhattan	20	21.56	2.20	6.75	3.40	0.71	10.86	......	2.99	3.63	53 00	30.5	18.2	13.1	8.7	......

Do	23	21.83	0.93	7.83	1.75	2.08	11.66	......	2.90	3.52	......	......	......	......	......	......
Abattoir Guano, E. F. Coe	42	16.24	1.59	7.39	4.11	......	11.50	3.92	3.32	4.02	50 00	22.8	13.6	9.8	......	8.7
Do	127	17.61	1.63	8.91	1.69	1.23	11.83	3.99	3.39	4.11	50 00	22.1	13.2	9.5	6.3	8.4
Ammoniated Superphosphate, E. F. Coe	117	19.16	1.25	10.22	2.80	1.66	14.68	......	2.54	3.08	42 00	20.4	12.1	8.7	5.8	......
Soluble Nitrogenous Phosphate, Quinnipiac Fertilizer Co	101	19.27	......	7.24	......	0.46	7.70	......	4.41	5.35	40 00	22.6	13.4	......	6.5	......
Do	146	16.15	......	8.16	3.39	2.55	14.10	......	3.33	4.00	40 00	19.3	11.4	8.3	5.5	......
Do	171	17.72	......	7.65	2.29	1.91	11.85	......	2.49	3.02	45 00	26.2	15.6	11.3	7.5	......
Pine Island Guano, Quinnipiac Fertilizer Company	99	15.93	......	4.95	2.32	1.93	9.20	......	5.64	6.84	45 00	22.1	13.2	9.5	6.3	......
Do	173	18.12	......	4.93	0.96	0.84	6.73	......	6.25	7.58	45 00	22.7	13.6	9.8	6.5	......
Charter Oak Fertilizer	110	13.45	8.64	8.57	......	9.07	17.64	......	1.77	2.14	......	......	......	......	......	......
Pacific Soluble Guano	116	10.29	......	5.06	1.50	7.23	13.79	4.62	2.42	2.93	45 00	24.4	14.5	10.4	4.6	9.3
Do	167	21.87	......	3.46	1.39	7.13	11.98	1.80	2.48	3.01	45 00	31.3	18.6	13.4	6.0	11.9
Sternfel's Ammoniated Dissolved Bones	120	16.83	5.83	2.64	2.31	0.44	5.39	......	2.09	2.53	40 00	41.9	24.9	17.9	12.0	......
Orient Ammoniated Bone Superphosphate	177	17.60	......	5.96	1.55	8.05	15.56	......	2.02	2.45	45 00	27.6	16.4	11.8	6.6	......
Bradley's Sea Fowl Guano	148	13.69	......	5.68	1.79	5.28	12.75	......	2.37	2.87	55 00	36.5	21.8	15.7	7.0	......
SLAUGHTER-HOUSE PRODUCTS.																
Animal Fertilizer, Brighton Abattoir	153	9.92	......	......	......	......	11.90	......	6.53	7.92	40 00	20.1	......	......	5.8	......
Acidulated Animal Fertilizer, Brighton Abattoir	31	17.59	......	6.37	......	1.11	7.48	......	5.33	6.47	40 00	21.2	12.6	......	6.1	......
Do	154	17.26	......	7.85	0.59	......	8.44	......	7.60	9.22	45 00	17.9	10.7	7.7	......	......

TABLE II.

Peruvian guanos.

Name of fertilizer.	Station number.	ANALYSES.										VALUATIONS.					
				Phosphoric acid.								Retail price per ton.	Cost of one pound each of valuable ingredients, at prices stated.				
				Available.										Phosphoric acid.			
		Moisture.	Sand, &c.	Soluble in water.	Soluble in ammonium citrate.	Insoluble.	Total.	Potash.	Nitrogen.	Ammonia equivalent to nitrogen.		Nitrogen.	Soluble in water.	Soluble in ammonium citrate.	Insoluble.	Potash.
		Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.		Cents.	Cents.	Cents.	Cents.	Cents.
No. 1, Peruvian Guano—"Standard"	16	16.60	......	5.75	(*)	11.69	17.44	(*)	9.37	11.37	......	......	......	......	......	......
Do	47	11.40	2.10	4.14	8.81	2.42	15.37	2.33	11.33	13.75	$60 00	15.6	9.3	6.7	4.5	6.0
Do	108	21.57	......	5.25	9.82	2.86	17.90	3.24	8.56	10.39	60 00	16.7	9.9	7.2	4.8	6.4
Do	137	13.06	......	5.27	6.24	4.01	15.52	4.36	7.76	9.42	58 50	17.8	10.6	7.6	5.1	7.0
Do	164	15.30	......	6.05	5.59	1.39	13.03	4.60	7.52	9.12	57 00	18.2	10.8	7.8	5.2	6.9
Do	166	12.63	......	5.55	3.44	5.15	14.14	4.06	6.95	8.43	57 00	19.3	11.5	8.3	5.5	7.4
Do	191	14.88	......	5.11	7.10	5.04	17.25	3.54	7.88	9.57	†58 00	17.3	10.3	7.4	4.9	6.6
Do	245	8.06	1.89	3.67	4.35	3.85	11.87	3.07	8.48	10.29	58 00	20.2	12.1	8.7	5.8	7.7
Average of above eight samples	......	14.19	......	5.10	6.48	3.53	15.31	3.60	8.48	10.29	58 00	17.1	10.2	7.3	4.9	6.5
No. 1, Peruvian Guana—Guaranteed (Cargo A)	186	13.11	11.39	4.55	4.35	7.10	16.00	3.45	5.87	7.12	56 00	20.1	12.1	8.7	5.8	7.7
Do	187	12.54	11.26	4.50	5.11	7.49	17.10	3.36	5.79	7.03	56 00	19.9	11.8	8.5	5.7	7.6
No. 1, Peruvian Guano—Rectified	57	12.61	1.80	10.67	None.	1.71	12.38	2.43	9.15	11.10	60 00	17.7	10.5	......	5.1	6.7
Do	136	14.90	......	10.02	2.82	None.	12.84	4.34	7.82	9.49	65 00	19.5	11.6	8.3	......	7.4
Peruvian Guuno—"Lobos"	243	10.80	......	6.80	6.68	4.13	17.61	4.23	4.68	5.68	49 00	17.0	10.1	7.3	4.9	6.5
Peruvian Guano, No. 2	244	8.23	38.60	4.01	7.81	2.12	14.04	2.67	2.60	3.16	49 50	19.8	11.8	8.5	5.7	7.6

* Not determined. The insoluble, 11.69, includes that soluble in ammonium citrate.

† Assumed price. Nos. 16 and 47 were bought in 1875.

TABLE III.

Fish manures.

Name of fertilizer.	Station number.	Analyses: Moisture.	Analyses: Sand, &c.	Analyses: Phosphoric acid.	Analyses: Nitrogen.	Analyses: Ammonia equivalent to nitrogen.	Retail price per ton.	Cost per pound: Nitrogen.	Cost per pound: Phosphoric acid.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Cents.*	*Cents.*
DRY GROUND FISH.									
Ground Fish, G. W. Miles	10	18.74	....	7.65	8.06	9.78	$45 00	20.2	8.1
Fish Guano, G. W. Miles	28	21.96	2.70	8.66	6.07	7.36	40 00	20.9	8.4
C. Island Guano, G. W. Miles	80	8.63	1.43	7.74	8.84	10.73	....	....	....
Allyn's Fertilizer	24	....		6.17	8.80	10.68	40 00	17.7	7.1
Do	185	6.34	....	7.90	7.88	9.56	40 00	18.1	7.2
Dry Ground Fish, Qunnipiac Fertilizer Co	100	14.64	....	6.67	7.50	9.11	45 00	22.1	8.8
Do	140	10.85	....	7.21	7.38	8.97	45 00	21.9	8.8
Do	172	13.45	....	7.55	7.96	9.66	45 00	20.5	8.2
Do	203	8.22	....	8.11	8.25	10.00	45 00	19.6	7.8
Acidulated Fish, Quinnipiac Fertilizer Co	222	36.53	....	*7.09	4.11	4.99	....	....	....
DRIED FISH-SCRAP.									
"Dry Fish," Green Brothers	179	11.04	....	10.51	8.60	10.44	28 00	10.9	4.4
"Dried Fish"	182	9.37	....	....	8.13	9.86	....	....	....
"Dry Fish"	189	11.00	....	....	7.46	9.05	....	....	....
"Fish Scrap"	190	7.74	....	....	7.10	8.61	....	....	....
"Dry Fish"	196	7.59	....	....	7.79	9.46	....	....	....
Do	199	....	....	....	7.65	9.28	....	....	....
HALF-DRY FISH-SCRAP.									
Fish Scrap, "Half Dry"	103	40.95	....	6.23	5.33	6.47	16 00	10.2	4.1
Do	131	25.10	2.52	7.49	5.49	6.66	16 00	9.4	3.8
Do	197	56.85	....	....	3.63	4.41	....	....	....

* Soluble in water, 1.76 per cent.; soluble in ammonium citrate, 2.47 per cent.

8. *Improved methods of drying fish scrap.*

The Hogle patent drying machine, manufactured at the works of H. B. Bigelow, New Haven, Conn., consists of a boiler containing several iron cylinders, in which the scrap is placed after it has been taken from the press, and where it is quickly dried by steam-heat. One of these machines is said to convert a ton of scrap into dry guano in an hour's time. The guano prepared in this way brings a much higher price than the ordinary scrap. An item in the New York Herald of July 22, 1872, stated that the former would command the price of $35 per ton, while ordinary scrap is worth $14. Ordinary scrap contains from 5.06 to 10 per cent. of ammonia, while this contains 15.

Mr. Maddocks remarks:

"With reference to drying by artificial means, which is obviously important, no doubt is felt that the apparatus now in operation will effect the work as thoroughly as may be desired, and cheaply and quickly also, provided only the oil in the scrap be reduced as above described.

"Two companies belonging to the association have succeeded in drying the scrap in considerable quantities, notwithstanding the obstacles referred to. The scrap is passed through a slightly-inclined heated iron cylinder, 30 feet long and 4 feet in diameter, and on the passage is agitated by paddles attached to a revolving shaft, and comes out at the lower end dried to about 25 per cent. of moisture. The process will be greatly promoted in dispatch and efficiency by the application of the new oil-saving method, and the whole manufacture will then be under full control. The scrap can at once, upon withdrawal from the press, be subjected to the drying process by furnace heat, irrespective of the state of the weather, and thus the loss of oil by leakage, mentioned above, and of ammonia by decomposition, be forestalled. If the contained moisture is reduced to a per cent. no lower even than 20 or 25, the scrap can be kept on the spot at convenience, and without offense to the senses, or transported as required."

In early days the fish-scrap was not dried, but was allowed to ferment in great heaps, sometimes not even protected from the weather At the old-fashioned oil-works may still be seen these heaps of foul decaying fish, filled with maggots and flies. Salt is sometimes added; also kainit, or sulphuric acid. These arrest decay for a time, though nothing is so effective as a thorough drying process.

APPENDIX P.

EXPORTS OF MENHADEN OIL FROM THE PORT OF NEW YORK, FROM JANUARY, 1875, TO JULY, 1878.*

Date.	Quantity in barrels.	Vessel.	Destination.
1875.			
Jan. 9	85	Steamship Utopia	Glasgow.
14	100	Steamship State of Nevada	Do.
27	40	Steamship State of Indiana	Do.
Feb. 16	14	Steamship State of Georgia	Do.
26	100	Bark H. L. Routh	London.
Apr. 3	64	Steamship Great Western	Bristol.
9	25	Steamship State of Louisiana	Glasgow.
9	75	Steamship Bolivia	Do.
10	50	Steamship Celtic	Liverpool.
15	50	Steamship Italy	London.
May 1	120	Steamship Cornwall	Bristol.
1	250	Steamship France	Havre.
4	50	Steamship Manhattan	Liverpool.
6	190	Steamship State of Georgia	Glasgow.
21	200	Steamship State of Louisiana	Do.
22	200	Steamship Ethiopia	Do.
26	1,500	Bark G. E. Cann	Havre.
29	5	Steamship Britannic	Liverpool.
June 5	80	Steamship Arragon	Bristol.
12	75	Steamship Pereire	Havre.
16	20	Steamship State of Georgia	Glasgow.
19	66	Steamship Cornwall	Bristol.
July 2	545	Steamship Italia	Glasgow.
2	82	Steamship State of Louisiana	Do.
3	478	Steamship Ethiopia	Do.
8	123	Steamship Somerset	Bristol.
9	100	Steamship Ville de Paris	Havre.
10	40	Steamship The Queen	Liverpool.
15	35	Steamship State of Indiana	Glasgow.
17	182	Steamship Elysia	Do.
23	62	Steamship Amerique	Havre.
24	169	Steamship California	Glasgow.
29	265	Steamship State of Georgia	Do.
31	135	Steamship Victoria	Do.
Aug. 3	270	Steamship Nevada	Liverpool.
6	10	Steamship Pereire	Havre.
6	420	Steamship Cornwall	Bristol.
12	100	Steamship State of Pennsylvania	Glasgow.
14	432	Steamship Great Western	Bristol.
19	5	Steamship Gellert	Hamburg.
20	150	Steamship France	Havre.
21	421	Steamship Bolivia	Glasgow.
21	211	Steamship Somerset	Bristol.
26	307	Steamship State of Indiana	Glasgow.
28	170	Steamship Elysia	Do.
31	50	Steamship Idaho	Liverpool.
Sept. 2	165	Steamship State of Virginia	Glasgow.
3	200	Steamship Ville de Paris	Havre.
4	592	Steamship Assyria	Glasgow.
4	700	Steamship California	Do.
4	185	Steamship Arragon	Bristol.
6	70	Steamship Montana	Liverpool.
6	150	Steamship Britannic	Do.
15	300	Steamship Olympia	Glasgow.
17	651	Steamship Utopia	Do.
22	916	Steamship State of Pennsylvania	Do.
22	2,193	Bark Floka	London.
25	189	Steamship Bolivia	Glasgow.
Oct. 1	135	Steamship France	Havre.
2	331	Steamship Ethiopia	Glasgow.
7	277	Steamship State of Virginia	Do.
15	175	Steamship Somerset	Bristol.
21	105	Steamship State of Georgia	Glasgow.
30	100	Bark Helen	Halifax.
Nov. 3	105	Steamship Arragon	Bristol.
18	50	Steamship State of Virginia	Glasgow.
Dec. 3	100	Steamship State of Indiana	Do.
4	65	Steamship Anchoria	Do.
10	60	Steamship Glenartney	London.
21	110	Ship K. Fish	Do.

*Compiled by Jasper Pryer, with William Warden, commission and shipping merchant, 88 Wall street, New York.

Exports of menhaden oil from the port of New York, &c.—Continued.

Date.	Quantity in barrels.	Vessel.	Destination.
*1876.			
June 1	206	Steamship State of Pennsylvania	Glasgow.
9	300	Steamship France	Havre.
14	159	Ship Jno. Bertiam	London.
15	60	Steamship State of Virginia	Glasgow.
July 5	140	Steamship Wyoming	Liverpool.
11	35	Steamship Cornwall	Bristol.
15	141	Steamship Bolivia	Glasgow.
27	140	Steamship State of Virginia	Do.
29	50	Steamship Britannic	Liverpool.
Aug. 1	100	Bark Arno	London.
8	209	Steamship Greece	Do.
9	140	Steamship Arragon	Bristol.
12	100	Steamship Germain	Havre.
12	184	Steamship Ethiopia	Glasgow.
19	500	Steamship Labrador	Havre.
25	100	Steamship Canada	Do.
26	774	Steamship Bolivia	Glasgow.
28	500	Bark Joshua Loring	Havre.
30	10	Ship Lina	Hamburg.
Sept. 6	210	Steamship Somerset	Bristol.
9	105	Steamship Anchoria	Glasgow.
15	106	Steamship State of Nevada	Do.
16	249	Steamship California	Do.
16	101	Steamship France	Havre.
22	60	Steamship State of Indiana	Glasgow.
30	70	Steamship Assyria	Bristol.
Oct. 2	46	Steamship Victoria	Glasgow.
3	200	Steamship Wyoming	Liverpool.
6	87	Steamship State of Pennsylvania	Glasgow.
7	5	Steamship Bolivia	Do.
20	41	Steamship State of Virginia	Do.
Nov. 24	95	Steamship Arragon	Bristol.
Dec. 1	107	Steamship Cornwall	Do.
2	22	Steamship Anchoria	Glasgow.
1877.			
Jan. 25	100	Bark Vicenzo Pirotto	Bristol.
29	139	Steamship Cornwall	Do.
Feb. 5	65	Bark Spirito	Do.
16	176	Steamship Somerset	Do.
26	39	Steamship Anchoria	Glasgow.
28	113	Steamship Arragon	Bristol.
Mar. 3	75	Steamship California	Glasgow.
6	200	Bark Johanna Wilhelm	Havre.
15	447	Bark Prinz Frederick Carl	London.
17	96	Steamship Cornwall	Bristol.
19	152	Steamship Assyria	Glasgow.
20	200	Steamship Labrador	Havre.
24	70	Steamship Bolivia	Glasgow.
27	150	Steamship Dakota	Liverpool.
April 2	75	Steamship Somerset	Bristol.
5	150	Steamship State of Nevada	Glasgow.
14	65	Steamship California	Do.
21	70	Steamship Ethiopia	Do.
25	100	Steamship Ville de Paris	Havre.
May 1	500	Steamship Labrador	Do.
3	200	Steamship State of Pennsylvania	Glasgow.
5	589	Steamship Bolivia	Do.
7	350	Steamship Caledonia	Do.
9	350	Steamship Canada	Havre.
10	175	Steamship Scythia	Liverpool.
12	245	Steamship Alsatia	Glasgow.
14	71	Steamship Somerset	Bristol.
15	100	Steamship France	Havre.
18	80	Steamship State of Nevada	Glasgow.
19	794	Steamship Anchoria	Do.
23	100	Steamship Pereire	Havre.
29	100	Ship Subra	London.
June 2	45	Steamship Alexandria	Glasgow.
2	107	Steamship Ethiopia	Do.
6	70	Steamship Arragon	Bristol.
9	35	Steamship Victoria	Glasgow.
12	200	Steamship Labrador	Havre.
14	239	Steamship State of Pennsylvania	Glasgow.
16	204	Steamship Bolivia	Do.
16	100	Ship C. H. Southard	London.

*There were none exported from January 1 to June 1, during 1876.

Exports of menhaden oil from the port of New York, &c.—Continued.

Date.	Quantity in barrels.	Vessel.	Destination.
1877.			
June 18	105	Bark John Reel	Havre.
21	147	Steamship State of Nevada	Glasgow.
23	142	Steamship Dorian	Bristol.
25	40	Steamship Devonia	Glasgow.
25	555	Ship Empire of Peace	Liverpool.
26	100	Steamship Pereire	Havre.
28	185	Steamship Cornwall	Bristol.
July 9	68	Steamship Guillermo	Do.
9	200	Ship R. J. Moulton	Havre.
9	40	Steamship Devonia	Glasgow.
11	137	Steamship Somerset	Bristol.
13	137	Ship Tewkesbury	Liverpool.
14	231	Steamship Ethiopia	Glasgow.
26	76	Steamship Suevia	Hamburg.
30	201	Steamship Devonia	Glasgow.
Aug. 3	25	Steamship Peloia	Bristol.
4	75	Steamship Utopia	London.
6	33	Steamship Caledonia	Bristol.
18	63	Steamship Scandinavian	Do.
21	135	Steamship St. Laurent	Havre.
Sept. 5	70	Steamship Labrador	Do.
11	70	Steamship Alexandria	Bristol.
14	2	Ship Crusader	Havre.
Oct. 9	75	Steamship Amerique	Do.
9	35	Steamship Cornwall	Bristol.
Dec. 29	201	Bark Enigma	London.
1878.			
Jan. 18	200	Bark Gyda	Do.
Mar. 16	300	Ship Pauline	Do.
21	300	Ship Europa	Do.
28	50	Steamship Anglia	Do.
29	50	Steamship Arragon	Bristol.
30	1	Steamship Andes	Port au Prince.
Apr. 4	1	Steamship Etna	Savanillia.
17	150	Steamship Scandanavian	Bristol.
18	91	Steamship Somerset	Do.
25	90	Ship S. E. Messinger	Havre.
25	1	Steamship Atlas	Kingston.
30	2	Bark Anlsa	Savanillia.
May 1	150	Ship Favorite	London.
8	101	Steamship Anglia	Do.
13	350	Ship Alhambra	Havre.
13	40	Steamship Devonia	Glasgow.
16	85	Steamship Baltic	Liverpool.
18	75	Steamship Anchoria	Glasgow.
25	60	Steamship Adriatic	Liverpool.
28	200	Steamship Pereire	Havre.
28	200	Ship Joseph	Do.
29	27	Steamship Herder	Hamburg.
June 1	60	Steamship Britannic	Liverpool.
1	30	Steamship Castalia	Glasgow.
1	200	Ship L. L. Sturges	London.
1	175	Steamship Ethiopia	Glasgow.
1	56	......do	Do.
5	1	Bark Victor	Falmouth.
5	252	Ship J. A. Stamler	Havre.
5	248	......do	Do.
5	168	......do	Do.
7	2	Steamship Atlas	Kingston.
12	139	Steamship St. Laurent	Havre.
12	167	......do	Do.
12	6	Steamship Santiago de Cuba	Havana.
15	784	Bark H. L. Routh	Glasgow.
15	95	Steamship Germanic	Liverpool.
15	104	Steamship Lepanto	Hull.
17	56	Steamship Wyoming	Liverpool.
18	143	Steamship Labrador	Havre.
25	179	Ship Precrossa	Do.
27	50	Steamship Utopia	London.
27	626	Ship James Foster, jr	Liverpool.

NOTE.—From other ports in United States, 2,600 barrels.

APPENDIX Q.

SUPPLEMENTARY NOTES.

NOTE.—Since sending the manuscript of this report to press, several valuable contributions to the knowledge of the menhaden and the menhaden industry have been received. In order to bring the discussion of the subject up to date these have been included in an appendix, with references prefixed, which show their proper connection in the body of the report.

GLOUCESTER, MASS., *September* 22, 1878

---

1. *An early allusion to the fat-back on the Southern coast.*

(Paragraph 28, p. 14.)

Catesby, in his Natural History of the Carolinas, Florida, and the Bahamas, 1731–1742, Vol. II, p. xxxiii, makes the following allusions to the "fat-back" or menhaden:

"Herrings in *March* leave the salt Waters and run up the Rivers and shallow Streams of fresh Water in such prodigious Sholes that people cast them on Shore with Shovels. A Horse passing these waters unavoidably tramples them under his Feet; their Plenty is of great Benefit to the inhabitants of many Parts of *Virginia* and *Carolina*. But the most extraordinary Inundation of Fish happens annually a little within the northern Cape of *Chesapick* Bay in Virginia, where there are cast on Shore usually in *March*, such incredible Numbers of Fish, that the Shore is covered with them a considerable Depth, and three Miles in length along the Shore. At these Times the Inhabitants from far within Land come down with their Carts and carry away what they want of the Fish; there remaining to rot on the Shore many Times more than sufficed them: From the Putrefaction that this causes the place has attained the Name of *Maggoty Bay*.

"These Fish are of various Kinds and Sizes, and are drove on Shore by the Pursuit of Porperses and other voracious Fish, at the general Time of Spawning; amongst the Fish that are thus drove on Shore is a small fish called a *Fat-back;* it is thick and round, resembling a Mullet but Smaller. It is an excellent Sweet Fish, and so excessive fat that Butter is never used in frying, or any other Preparation of them. At certain Seasons and Places there are infinite Numbers of these Fish caught, and are much esteemed by the Inhabitants for their Delicacy"

2. *Departure of the schools in the fall.*

(Section 12, p. 38.)

Mr. Charles G. Atkins, in a letter to Professor Baird, March 9, 1878 (Bucksport, Me.), states that young menhaden were more abundant than

ever in the fall of 1877. Sometimes at a single tide each net-fisherman would catch at his "berth" thirty or forty individuals. They continued to take them until January.

Mr. H. L. Dudley, of Pine Island, states that the season in Eastern Long Island Sound has usually opened May 1 to May 10, and closed about November 15. In 1877 some fish were caught after December 1, and in 1878 his steamer caught 125,000, April 15, the earliest catch ever known.

3. *The spawning-grounds of the menhaden.*

(Paragraph 133, p. 99.)

Evidence now tends to show that some of the schools, at least, defer spawning until the season of their approach to the coast in April. Like the mackerel, they seem to come into the shoal water along the shores of the Middle States and Southern New England laden with ripe ova, which they may deposit either on the sandy bottoms at a distance from land or in the entrance to the broad bays. With this new light I am prepared to believe that certain schools spawn in the rivers and sounds of the Southern States from Florida to North Carolina, as is confidently stated by several of our correspondents; indeed, I have had several strong testimonies from persons in Florida since writing paragraph 133. Although the facts are not sufficient to determine whether menhaden spawn on a falling temperature, like the herring, or on a rising temperature, like the shad, the latter view appears to be gaining in weight.

Capt. Robert H. Hurlbert, of Gloucester, a close observer, whose statements about the mackerel and cod I have often had occasion to test and never found inaccurate, assures me that in 1875, when with the mackerel fleet on the southern coast, he saw a number of menhaden, full of spawn, taken in the seine with a school of mackerel, twelve miles south of the Five-Fathom Bank light-ship, off Delaware Bay. This was late in April.

In late April, 1877, again, he seined ten barrels of fat, large fish off Chincoteague Shoals, on the eastern shore of Virginia. Their abdomens were much extended, and all which were examined proved to be full of spawn. Captain Hurlbert has caught them and examined numbers of them later in the season after fishing began in Block Island Sound, but has never seen spawn in them.

Capt. Henry E. Webb, of Milk Island, Rockport, Mass., states that twenty years ago he was in the habit of catching menhaden in the neighborhood of Cape Ann. He caught a few large ones every year before the great schools came in. These he cut up for bait, and occasionally found them full of spawn. He has never seen spawn in them after the middle of May. When a boy, as early as 1848, he lived at Riverhead, N. Y., near the eastern entrance of Long Island Sound. He says that he was accustomed to catch multitudes of young menhaden in a musquito-net seine toward the end of summer. These little fish

when they first came into the creeks were transparent and about half an inch long, but increased rapidly in size toward the end of the season, and in the fall measured four or five inches.

The parallelism between these facts and those connected with the spawning of the mackerel is very apparent. I regret that I must send this paper to press with the question of the spawning habits of the menhaden in such an unsatisfactory condition.

4. *Menhaden fishing on a Long Island steamer.*

[From advance sheets of an article entitled "Around the Peconics," by ERNEST INGERSOLL, in Harper's New Monthly Magazine for October 1, 1878, pp. 719-723.]

(Paragraph 174, p. 124.)

Loitering in comfortable indecision, I was fortunate enough to get an invitation from Captain "Jed" Hawkins to take a fishing cruise in his "bunker" steamer. The start was to be made at earliest dawn—an ungracious hour—and I was glad to leave the hotel in the evening, and avail myself of a sofa in the captain's snug state-room behind the pilot-house, so as to avoid the annoyance of getting up in the middle of the night. It was Sunday, and the little wharf was utterly deserted as I picked my way among the rubbish and piles of merchandise down to the steamer. Standing on the high deck, a picture of serene beauty spread before me. The air was perfectly still, the moon just fairly risen, and no sound was to be heard save the ticking of that mighty time-piece the tide, as its wavelets swung gently back and forth under the weedy piers or divided against the sharp prows of the smacks. It was light enough to show the spars and ropes of every craft, and all lay as motionless as though fixed in rock rather than floating in liquid, save the tremulous blue pennons on the topmasts. Then I turned in; and when I emerged, after an hour's pounding on my door (as it seemed) by the chuggety-chugging engines, we were far down Gardiner's Bay.

Last night the unruffled water was like bronze; now, under the soft silvery haze of the morning, the dancing surface became frosted silver, opaque and white save where the early sunbeams, striking through the mist, were reflected from the crests of the ripples in glancing ribbons of light. Shelter Island was an indistinguishable mass far astern; Long Beach light had ceased to twinkle; Orient Point was hidden in haze; Plumb Island, where eagles used to make their metropolis, and many fish-hawks now live, nesting on the ground with the gulls, was only a low bank of blue; Gull Islands could not be seen at all; and I only knew that Little Gull with its copper-bolted wall was there from the dot in the horizon made by its lonely light-house, and an occasional gleam imagined to be the surf breaking on the reefs at the Race. All this was northward. Southward the wooded bluffs of Gardiner's Island, with its natural breakwater and light-house, like a long arm reaching out between the outer and the inner waters, limiting the view. But this was soon left behind, and as the deep indentation of Napeague

came into view, the steamer's head was turned southeastward, toward Montauk, which, in the growing light, now stood out plain in every bleak feature of sandy dune and treeless moor. Now a very sharp look-out must be kept for fish, and after the substantial breakfast in the forecastle, I took my pipe and a place in the shrouds. Even then I could not look across Montauk, but could easily see two great ponds of fresh water, which nearly served to make an island of the Point. One of them, Fort Pond, was once a scene of sanguinary warfare between the Montauks and Narragansetts, the latter being beaten only by help from the Shelter Island Indians, who drove the invaders to their canoes.

Off Culloden Point the lookout excitedly announced, "Fish off the port bow!" The captain seized his glass, and scanned the water. So did I. "There's a big bunch," he shouts. "Watch 'em flirt their tails! Good color! See how red the water is!"

"O, yes; to be sure," I cry. "By Jove, that's a good color!"

My vacant face must have belied my words, but he didn't notice it. He was shouting, "Lower away the boats! Stand by to ship the nets!" furiously ringing signals to the engineer; giving hasty orders to the wheelsman; ensconcing himself in a pair of oil skin trousers, so capacious I half expected he would disappear altogether; and so, amid the roar of escaping steam, the creaking of davit tackle, the laughing excitement of the crews, and the rattle of rowlocks, I tumble head-foremost into a boat, and the steamer was left behind. Now the flirting of tiny tails was plainly visible, but I must confess that I did not learn to distinguish the reddish hue which indicates a school of these fish until much later in the day. The two large boats side by side were sculled rapidly toward the shore where the fish were seen, the forward part of each boat piled full of the brown seine, which extended in a great festoon from one to the other. There were four men in each boat, all standing up, and in our red shirts and shiny yellow oil-skin overalls we must have made a pretty picture on that sunny morning. Close by was a pound-net, where a porpoise was rolling gaily, notwithstanding his captivity; but by maneuvering we got the "bunch" turned away from it and well inshore, where the water was not too deep. At last we were close to them, and now came a scene of excitement.

"Heave it!" yelled the captain, and in each boat a sailor whose place it was, worked like a steam-engine throwing the net overboard, while the crews pulled with all their muscles in opposite directions around a circle perhaps a hundred yards in diameter, and defined by the line of cork buoys left behind, which should inclose the fish. In three minutes the boats were together again; the net was all paid out; an enormous weight of lead had been thrown overboard, drawing after it a line rove through the rings along the bottom of the seine. The effect, of course, was instantly to pucker the bottom of the net into a purse, and thus,

before the poor bunkers had fairly apprehended their danger, they were caught in a bag whose invisible folds held a cubic acre or two of water.

This was sport! I had not bargained for the hard work to come, to the unsportive character of which my blistered palms soon testified.

None of the fish were to be seen. Every fin of them had sunk to the bottom. Whether we had caught ten or ten thousand remained to be proved. Now, lifting the net is no easy job. The weight of nearly ten thousand square yards of seine is alone immense, but when it is wet with cold sea-water, and held back by the pushing of thousands of energetic little noses, to pull it into a rocking boat implies hard work. However, little by little it came over the gunwales, the first thing being to bring up the great sinker and ascertain that the closing of the purse at the bottom had been properly executed. Yard by yard the cork line was contracted, and one after another the frightened captives began to appear, some folded into a wrinkle or caught by the gills in a torn mesh (and such were thrown back), until at last the bag was reduced to only a few feet in diameter, and the menhaden were seen, a sheeny, gray, struggling mass, which bellied out the net under the cork lines and under the boats, in vain anxiety to pass the curious barrier which on every side hemmed them in, and in leaping efforts to escape the crowding of their thronging fellows. How they gleamed, like fish of jewels and gold! The sunshine, finding its way down through the clear green water, seemed not to reflect from their iridescent scales, but to penetrate them all, and illumine their bodies from within with a wonderful changing flame. Gleaming, shifting, lambent waves of color flashed and paled before my entranced eyes; gray as the fishes turned their backs, sweeping brightly back with a thousand brilliant tints as they showed their sides; soft, undefined, and mutable, down there under the green glass of the sea; while, to show them the better, myriads of minute medusæ hurried hither and thither, glittering like phosphorescent lanterns in gossamer frames and transparent globes.

All possible slack having now been taken in, the steamer approaches, and towing us away to deeper water, for we are drifting toward a lee shore, comes to a stand-still, and the work of loading begins. The cork line is lifted up and made fast to the steamer's bulwarks, to which the boats have already attached themselves at one end, holding together at the other. This crowds all the bunkers together in a mass between the two boats and the steamer's side, where the water boils with the churning of thousands of active fins. A twenty-foot oar is plunged into the mass, but will not suffice to sound its living depths. Then a great dipper of strong netting on an iron hoop is let down by tackle from the yard-arm, dipped into the mass under the guidance of a man on deck who holds the handle, the pony-engine puffs and shakes, and away aloft for an instant swings a mass of bunkers, only to be upset and fall like so much sparkling water into the resounding hold.

"How many does that dipper hold?"

"About a thousand."

"Very well, I will count how many times it goes after a load."

But I didn't. I forgot it in looking down the hatchway. The floor of the shallow hold was paved with animated silver, and every new addition falling in a lovely cataract from far overhead, seemed to shatter a million rainbows as it struck the yielding mass below, and slid away on every side to glitter in a new iridescence till another myriad of diamonds rained down. If you take it in your hand, the mossbunker is an ordinary-looking fish, like a small shad, and you do not admire it; but every gleaming fiery tint that ever burned in a sunset, or tinged a crystal, or painted the petals of a flower, was cast in lovely confusion into that rough hold. There lay the raw material of beauty, the gorgeous elements out of which dyes are resolved—abstract bits of lustrous azure and purple, crimson and gold, and those indefinable greenish and pearly tints that make the luminous background of all celestial sun-painting. As the steamer rolled on the billows, and the sun struck the wet and tremulous mass at this and that angle, or the whole was in the half-shadow of the deck, now a cerulean tint, now a hot brazen glow, would spread over all for an instant, until the wriggling mixture of olive backs and pearly bellies and nacreous sides, with scarlet blood-spots where the cruel twine had wounded, was buried beneath a new stratum.

"How many?" I asked when all were in.

"Hundred and ten thousand," replied Captain Hawkins. "Pretty fair, but I took three times as many at one haul last week."

"What are they worth?"

"Oh, something over a hundred dollars.—Hard a-starboard! go ahead slow."

And the labor of the engines drowned the spat, spat, spat of the myriads of restless little tails struggling to swim out of their strange prison, while I climbed to the mast-head to talk with the grizzly old lookout, who had been round Cape Horn thirteen times, yet did not think himself much of a traveler.

The cry of, "Color off the port bow!" brought us quickly down the ratlines and again into the boats.

That day we caught 250,000 fish, and made a round trip of a hundred miles, going away outside of Montauk Point, where it was frightfully rough after a two days' easterly gale. Great mountains of water, green as liquid malachite, rolled in hot haste to magnificent destruction on the beach, where the snowy clouds of spray were floating dense and high, and the roar of the surf came grandly to our ears wherever we went. Yet the difficulties were none too great for these hardy fishermen, who balanced themselves in their cockle-shells, and rose and sank with the huge billows, without losing their hold upon the seines or permitting a single wretched bunker to escape.

5. *The manufacture of sardines from menhaden.*

(Paragraph 189, p. 137.)

The New York Times, April 12, 1874, has the following account of the Port Monmouth factory:

"The scene at the fishing grounds off Sandy Hook at the height of the season is picturesque in the extreme. The day is usually a bright one, with just enough breeze to render the heat bearable and toss up the small white caps of the waves for the sunlight to sparkle on. The fishermen in their jaunty little ten-ton sloops have been lying off the 'grounds' since midnight. In the dim light of the early dawn the 'school' is descried approaching against the wind. The menhaden swims on the surface, and the serried ripples of myriads of fins cover the broad expanse for thousands of feet in every direction. The small boats are lowered, the long net, over 7,000 feet in length, and reaching 12 or 13 into the water, is carried out on both sides until the hapless fish are inclosed in a vast semicircle, through the meshy walls of which there is no escape, and from which they are ladled in thousands by the fishermen armed with small nets or 'scoops,' holding a peck apiece. The silly victims never think of escaping by swimming beneath the lower edge of the net, a few feet below the surface. The victims are then loaded on the sloops, which make sail as rapidly as possible for the factory dock at Port Monmouth. During rough or unusually breezy weather the general effect is greatly heightened. The flapping sails, careening boats, and spray-drenched fishermen, hauling on the seine with redoubled exertions in order to get in their catch before the wind freshens into a gale, forms a picture exhilarating even to old hands at the business. At the landing the fleet are greeted by the 180 employés in the factory, and the entire catch, often reaching a thousand bushels, is rapidly transferred to the shore. Then begins the more prosaic part of the process. The fish to be cured are selected from the catch, the medium-sized ones being preferred, their heads, tails, and entrails removed by a new machine, the exclusive property of the company, and their bodies transferred to the 'scalers.' Only from a half to a fifth of the original haul is used, two hundred bushels being the ordinary amount handled daily. These the 'scalers' seize and submit to the scraping-machine, a series of revolving curry-combs arranged on four lines of shafting 50 feet long, which frees each fish of its scales in the space of about a second and a half. As seventy or eighty men are at work, straining every nerve to get the 'catch' into the salt before the heat of the day, the rapidity with which the finny game are put through the various details is something startling. The 'cleaners' are long oval troughs of running water, over which revolves a series of brushes, something after the pattern of the 'scaler,' and which does all that its name implies in an almost equally short space of time. From this the fish go into the salting barrels, a stage of the work at which the men

take breath for the first time. In these the fish are allowed to remain for two or three hours, at the end of which they are thoroughly cured, and are transferred to the zinc-covered tables, 8 feet by 6, with raised edges. In this position water is poured on them, and afterwards drained off in tubes connecting with the corners. The cooking cans, tin boxes a little larger than the ordinary packing cans, next receive them, and are then placed in steam tanks, seven in number, of a capacity of a ton each. Here they are left for two hours, during which they are thoroughly cooked. After being taken out and packed in the regular market-cans, the fish are conveyed to other tables, on which the process of oiling is gone through. Olive-oil is poured on them until the cans can hold no more, and the latter then passed to the tinners, of whom the company employ thirty-five, to go through the process of soldering. From this department they are taken back into another set of steam-tanks to be heated for venting. When the tin is at a proper temperature the can is taken out and a small hole opened at one end, through which the hot air is suffered to escape, and the aperture is then hermetically sealed. In the room adjoining the cans are packed in wooden cases for shipping, two dozen to the case. The retail price per full-sized can, containing from seven to nine fish, is fifty cents; that of the same size of the French imported goods, $1.10 in gold. The buildings of the company include a large factory, 360 feet long by 120 broad, and from four to five stories in height, and a boarding-house for their employés. The former contains the necessary rooms for the various departments of the work already described, together with the machinery and equipments, most of which are original with the present enterprise. The engine used is of fifty horse-power, amply sufficient for all ordinary purposes. The company board and lodge all their hands, make all the tin-work, cans, &c., and keep their own teams and carts for hauling their goods to the dock at Port Monmouth. The pay-roll of the establishment, excluding the board and lodging of all the workmen, is about $3,000 a month, reaching during the busiest part of the season as high as $1,000 per week. The boarding-house contains accommodations for 180 men, including dining rooms, sleeping rooms, &c. Everything is kept clean and in order, and the health and comfort of the inmates sedulously cared for. A long dock has been constructed near the entrance to the main building, in 15 feet of water, where the sloops and boats unload their cargoes. Several hundred thousand dollars have been invested in the business, the facilities of which are being enlarged annually. Besides the home business, done with every State in the Union, the company ship large consignments to foreign ports, including Liverpool, Hamburg, and other places. At the Vienna Exposition of last year their contributions attracted much attention, and were unanimously awarded the gold medal of honor and the grand diploma of merit. An agency was also established in that city for Austria and Russia, which has since acquired a fine business. At home they have received flattering indorsements and

congratulations from the first business houses of New York, Saint Louis, Cincinnati, and the other great cities, all speaking in high terms of the flavor and delicacy of the American sardine, and reporting large sales of the article. So great has been the demand that up to the time of the panic they were unable to fill the orders pouring in from various parts of this country and Europe. The fishing season this year commences late, having been materially delayed by the cold weather. The 'schools,' however, are expected in the vicinity of Sandy Hook by the 1st of May, after which the work will be prosecuted night and day to the close of the season."

6. *Small oil-trying works in Maine*, 1860.

(Paragraph 229, p. 165.)

The Gloucester Telegraph of February 22, 1860, states that the inhabitants of Brooklin, Me., manufacture annually from 500 to 1,000 barrels of pogy oil, worth from $15 to $20 a barrel.

7. *The use of fish for manure by the early colonists of Massachusetts.*

(Paragraph 268, p. 195.)

The following order from the records of the town of Ipswich, Mass., May 11, 1644, illustrates, in a comical way, the custom of using fish for manure in those early days:

"It is ordered that all doggs, for the space of three weeks after the publishing hereof, shall have one legg tyed up, and if such a dogg shall break loose and be found doing any harm, the owner of the dogg shall pay damage. If a man refuse to tye up his dogg's legg, and hee bee found scrapeing up fish in a cornefield, the owner thereof shall pay twelve pence damages beside whatever damage the dogg doth. But if any fish their house lotts and receive damage by doggs, the owners of those house lotts shall bear the damage themselves."*

8. *A fish-fertilizer company in Boston*, 1860.

(Paragraph 282, p. 210.)

"A company was established in Boston in 1860, prepared to grant licenses for treating fish under the patent of Messrs. De Molon and Thurneyssen, dated March 6, 1855."†

* Coffin's History of Newbury, &c. Boston, 1845, p. 42.
† Cape Ann Advertiser, 1860.

EXPLANATION OF PLATES.

PLATE I.

Figure 1. *Brevoortia tyrannus* (p. 19), adult, 12 inches long, from Wood's Holl, Mass. Drawn by H. L. Todd.

PLATE II.

Figure 2. *Brevoortia tyrannus* (p. 19), young, 8 inches long, from Wood's Holl (No. 20,066 c). Drawn by H. L. Todd.

PLATE III.

Figure 3. *Brevoortia tyrannus*, subsp. *aurea* (p. 21). Drawn by H. L. Todd, from a specimen in the Museum of Comparative Zoology, Brazil.

PLATE IV.

Outlines showing the variations of *Brevoortia tyrannus* (p. 21):
Figure 4. *Brevoortia tyrannus*, subsp. *menhaden*, Wood's Holl.
Figure 5. *Brevoortia tyrannus*, subsp. *brevicaudata*, Noank, Conn.
Figure 6. *Brevoortia tyrannus*, subsp. *menhaden*, Saint John's River, Fla.
Figure 7. *Brevoortia tyrannus*, subsp. *aurea*, Brazil.

PLATE V.

Figure 8. *Brevoortia patronus* (p. 26), young? 8 inches long, from Brazos Santiago, Texas (892 a). Drawn by H. L. Todd.

PLATE VI.

Figure 9. *Brevoortia pectinata* (p. 30). Drawn by H. L. Todd, from a specimen in the Museum of Comparative Zoology, Rio Grande, Brazil.

PLATE VII.

Figure 10. *Brevoortia dorsalis* (p. 37), west coast of Africa. Outline from Bleeker's Plate.

PLATE VIII.

Figure 11. Fac-simile of plate accompanying Latrobe's description of *Clupea tyrannus* and *Oniscus prægustator*, (p. 15), from Transactions of the American Philosophical Society, Vol. V, 1802, Plate I.

PLATE IX.

Figure 12. Map showing geographical distribution of the North American menhaden, the annual movements of the schools, and the locations of the fishing-grounds and the oil-factories.

PLATE X.

Parasites of the menhaden. Drawn by J. H. Emerton:
Figure 13. Head of fish showing the position of the crustacean parasite (p. 102).
Figure 14. *Cymothoa prægustator* (p. 101).
Figure 15. *Lœmonema radiata* (p. 104).

PLATE XI.

Figure 16. Map of the menhaden fishing-grounds of Maine (from Maddocks' Report).

PLATE XII.

Figure 17. Diagram of temperature strata in the Atlantic Ocean between New York and the Bermudas, April 24 to May 8, 1873 (p. 66). Copied from the "Reports of Capt. G. S. Nares, R. N. (H. M. S. Challenger), with abstract of soundings and diagrams of ocean temperatures in the North and South Atlantic Oceans, 1873."

PLATE XIII.

Figure 18. Diagram of temperature strata in the Atlantic Ocean between Halifax, Nova Scotia, and the Bermudas, (p. 66). From Captain Nares's Report.

PLATE XIV.

Diagrams illustrating the use of a purse-seine (p. 117):

Figure 19. Section of seine showing cork-line and lead-line with bridle for pursing.

Figure 20. Lower part of purse-seine showing the arrangement of the pursing weight.

Figure 21. Diagram showing boat and method of pursing the seine.

PLATE XV.

Cape Ann seine-boat, with gear (p. 120). Drawn by J. H. Emerton:

Figure 22. Seine-boat, 88 feet long, showing seine in position, ready to be set; pump, and other fittings.

Figure 23. Section of stem of seine-boat, showing towing-links and gear.

Figure 24. Pursing-blocks, showing method of attachment to thwart of seine-boat.

Figure 25. Oar-rest and fastenings (new model).

Figure 26. Oar-rest (old model).

Figure 27. Purse-weight and pursing blocks.

PLATE XVI.

Figure 28. Cape Ann dory, with details of construction (p. 122).

Figure 29. Side of seining schooner, with seine-rollers.

PLATE XVII.

Figure 30. A menhaden seining steamer (p. 123). (From Maddocks' "The Menhaden Fishery of Maine.")

PLATE XVIII.

Figure 31. Diagram of the seining steamer "Leonard Brightman."

1. Pilot-house.
2. Gangway to forecastle.
3. Main hatch for stowage of fish.
4. Engine-house.
5. Towing-chocks.

PLATE XIX.

Figure 32. Seining menhaden at Cape Ann (p. 125). (From a sketch by Mr. P. Center.)

PLATE XX.

Figure 33. Seining menhaden in Peconic Bay (p. 124). From the "American Agriculturist."

PLATE XXI.

Figure 34. Maine steamers seining menhaden (p. 126). From a sketch by Henry W. Elliott.

PLATE XXII.

The preparation of menhaden for bait (p. 147). Drawn by J. H. Emerton:

Figure 35. Slivering menhaden.

Figure 36. Bait-mill, perspective view.

Figure 37. Bait-mill seen from above, showing knives.

Figure 38. Roller of bait-mill.

Figure 39. Bait or churn box, which, when in use, is fixed in the rigging, as shown in Plate XVI, Fig. 29.

Figure 40. Bait-dipper.

PLATE XXIII.

Figure 41. Knives for slivering menhaden (p. 147). Drawn by H. L. Todd.

1. Slivering knife, old style.
2. Slivering knife.
3. Slivering knife, modern style.
4. Slivering knife, old style.

PLATE XXIV.

Figure 42. Factory of AMERICAN SARDINE COMPANY at Port Monmouth, N. J., (p. 137). Cut lent by Mr. F. F. Beals.

PLATE XXV.

Figure 43. Factory of THE GEORGE W. MILES COMPANY on Charles Island, Milford, Conn., with floating factory "Alabama," (p. 171). Cut lent by Mr. Miles.

PLATE XXVI.

Figure 44. Factory at Napeague, N. Y. (p. 173). Cut lent by the "American Agriculturist."

PLATE XXVII.

Interior views of the factory at Napeague (p. 173): Cut lent by the "American Agriculturist."
Figure 45. Interior of the pot-works (old style).
Figure 46. Press-room (old style).
Cuts lent by the "American Agriculturist."

PLATE XXVIII.

Figure 47. Factory of Luther Maddocks at Booth Bay, Me. From "The Menhaden Fishery of Maine."

PLATE XXIX.

Figure 48. Factory of Joseph Church & Co. at Round Pond, Me. (p. 172). From "The Menhaden Fishery of Maine."

PLATE XXX.

Figure 49. The ship "Alabama" used by the George W. Miles Company for a floating factory (p. 171). From an India-ink drawing by H. L. Todd, copied by one of the photographic processes of Pennington & Co.

PLATE XXXI.

Figure 50. Factory of the Pacific Guano Company at Wood's Holl, Mass. Cut lent by the Company.

ALPHABETICAL INDEX.

D.

E.

F.

N.

Plate I.

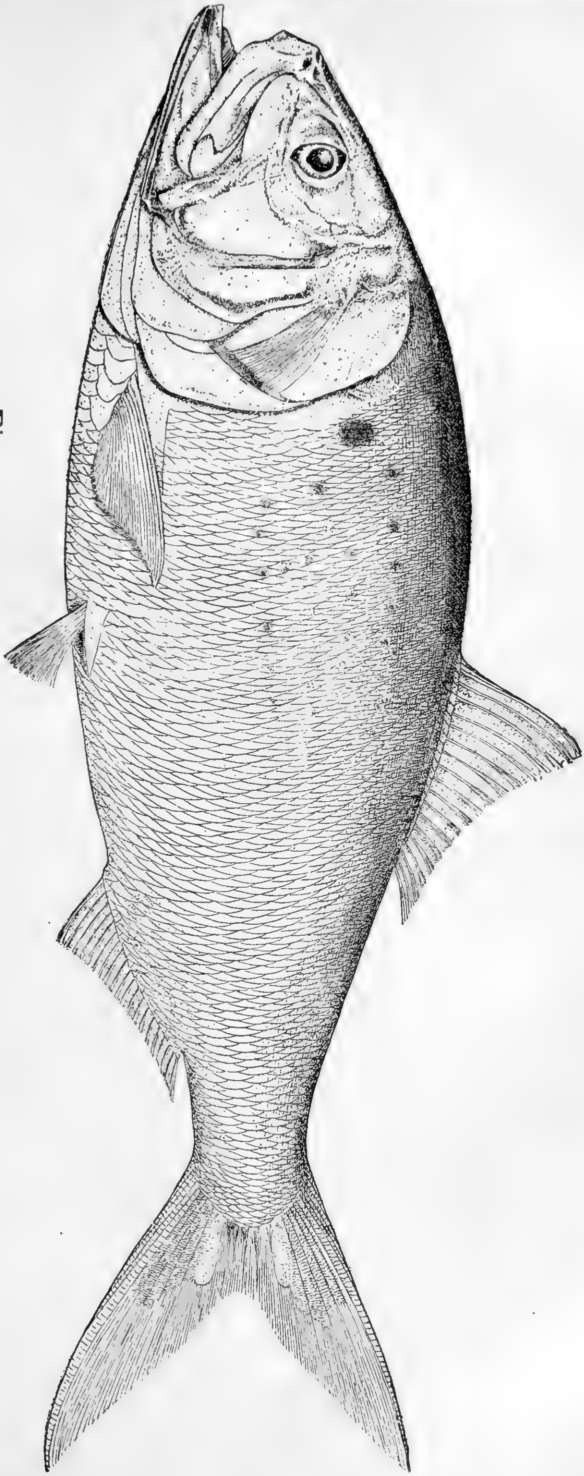


Fig. 1.

Plate II

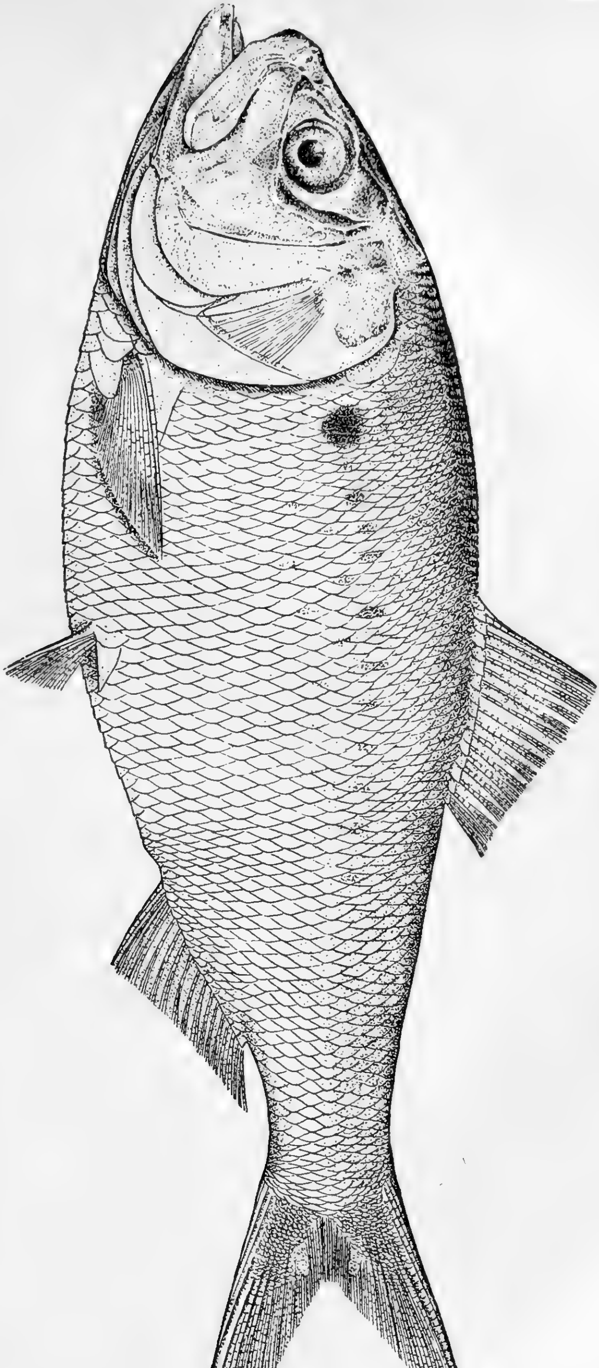
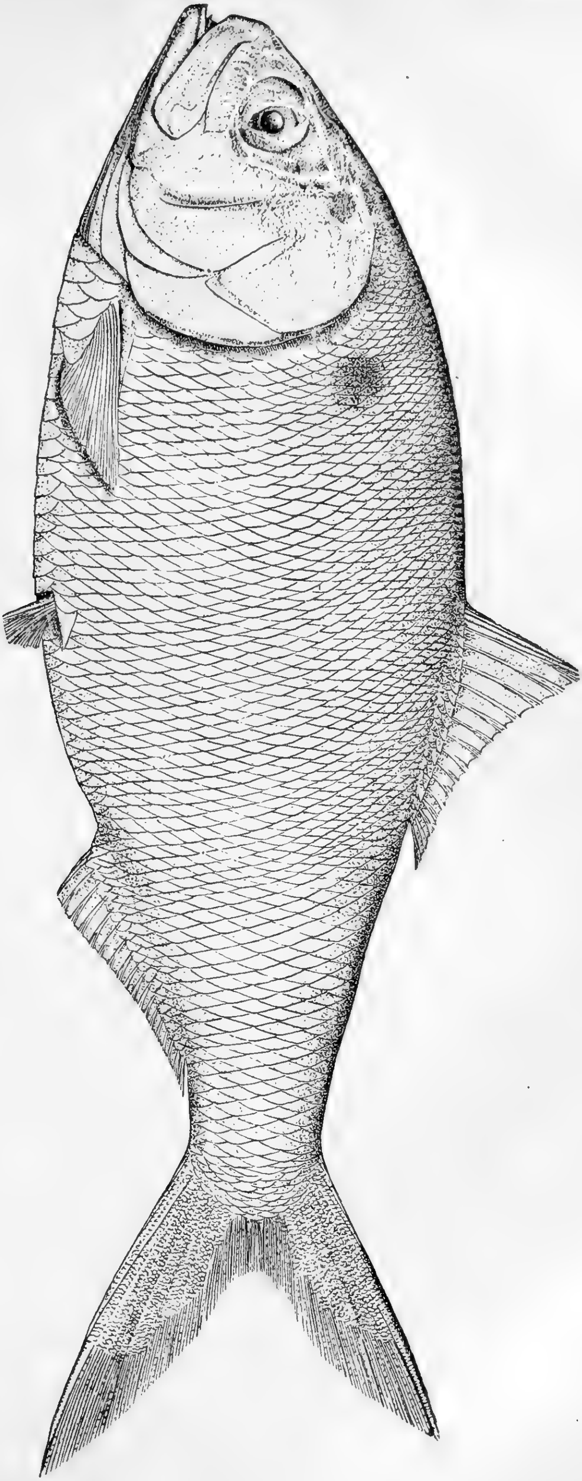


Fig. 2.

Plate III.

Fig. 3.



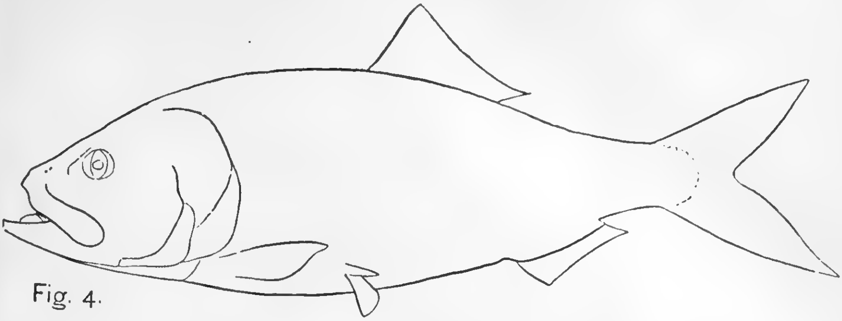


Fig. 4.

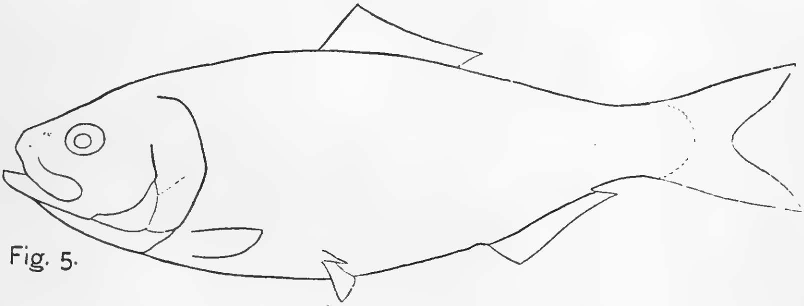


Fig. 5.

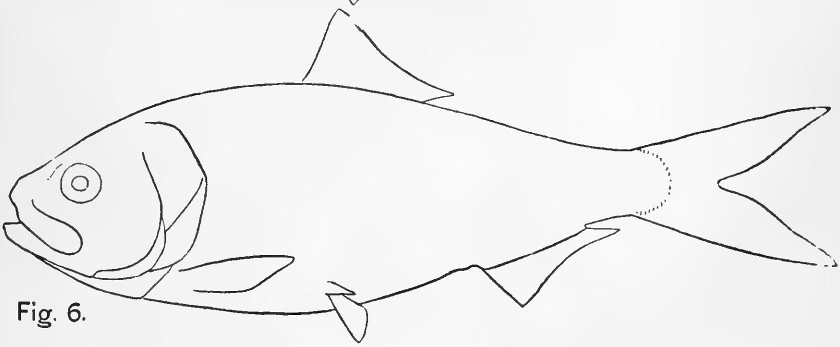


Fig. 6.

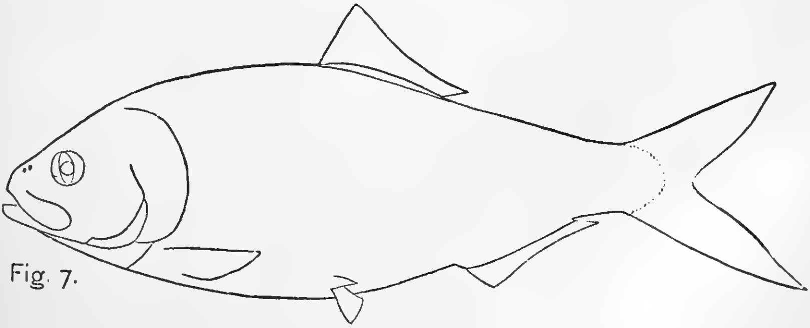


Fig. 7.

Plate V.

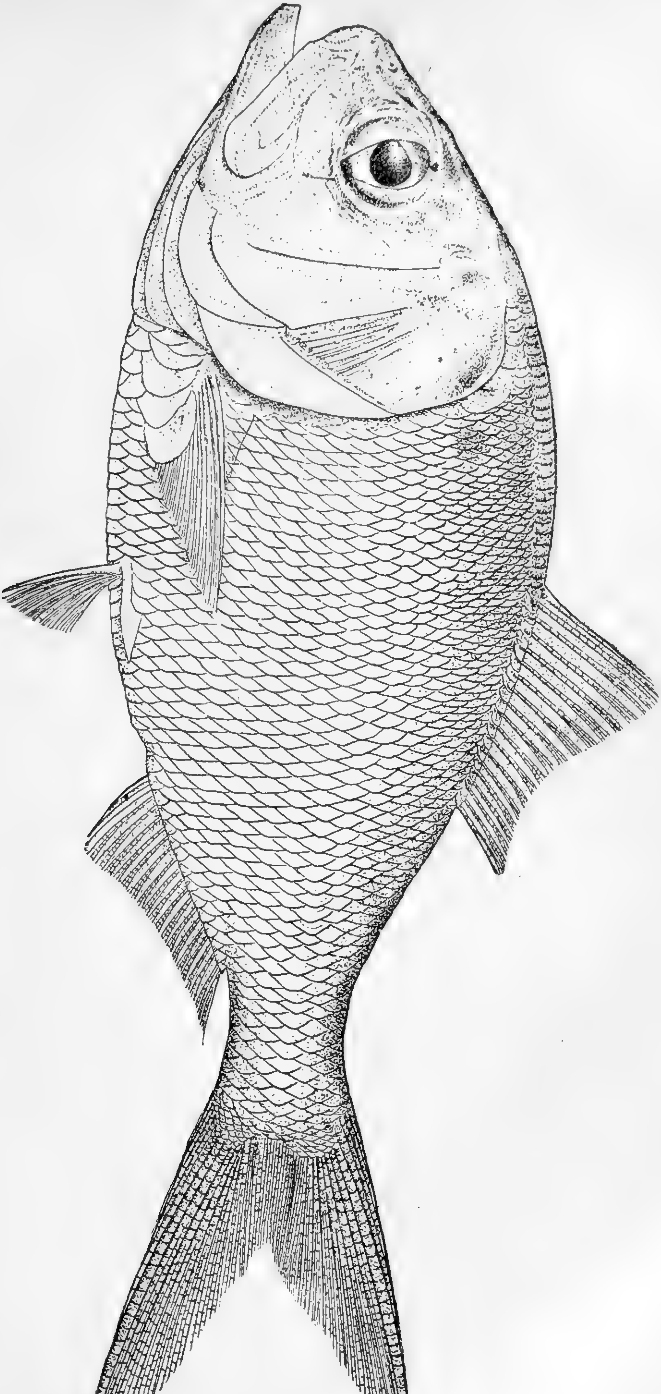
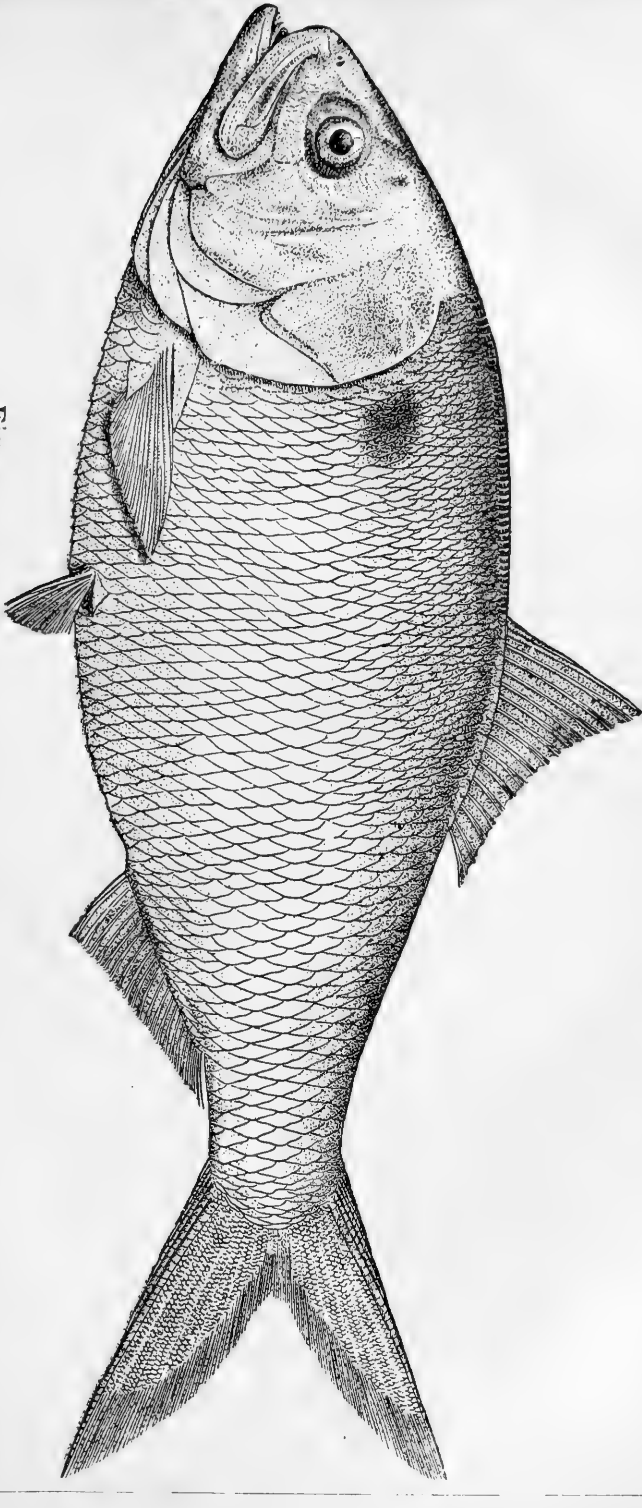


Fig. 8.

Plate VI.

Fig. 9.



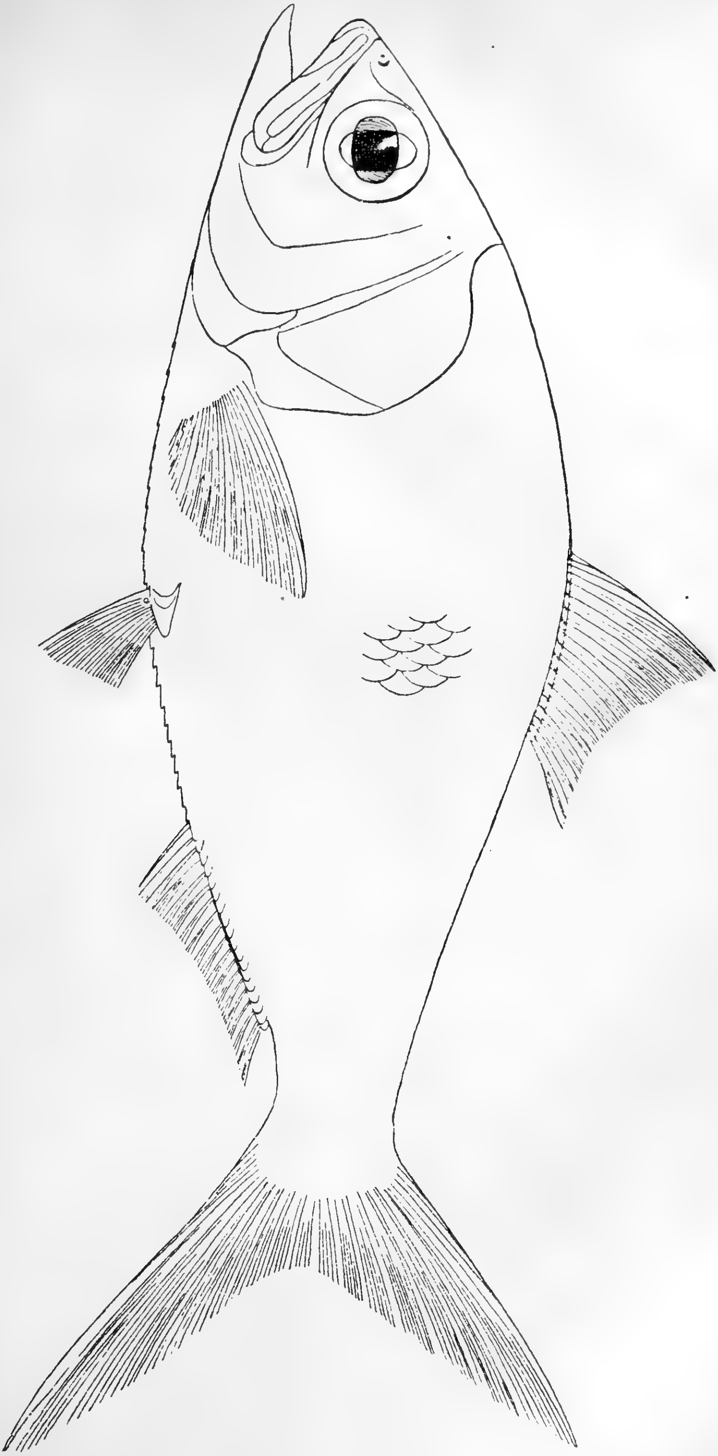
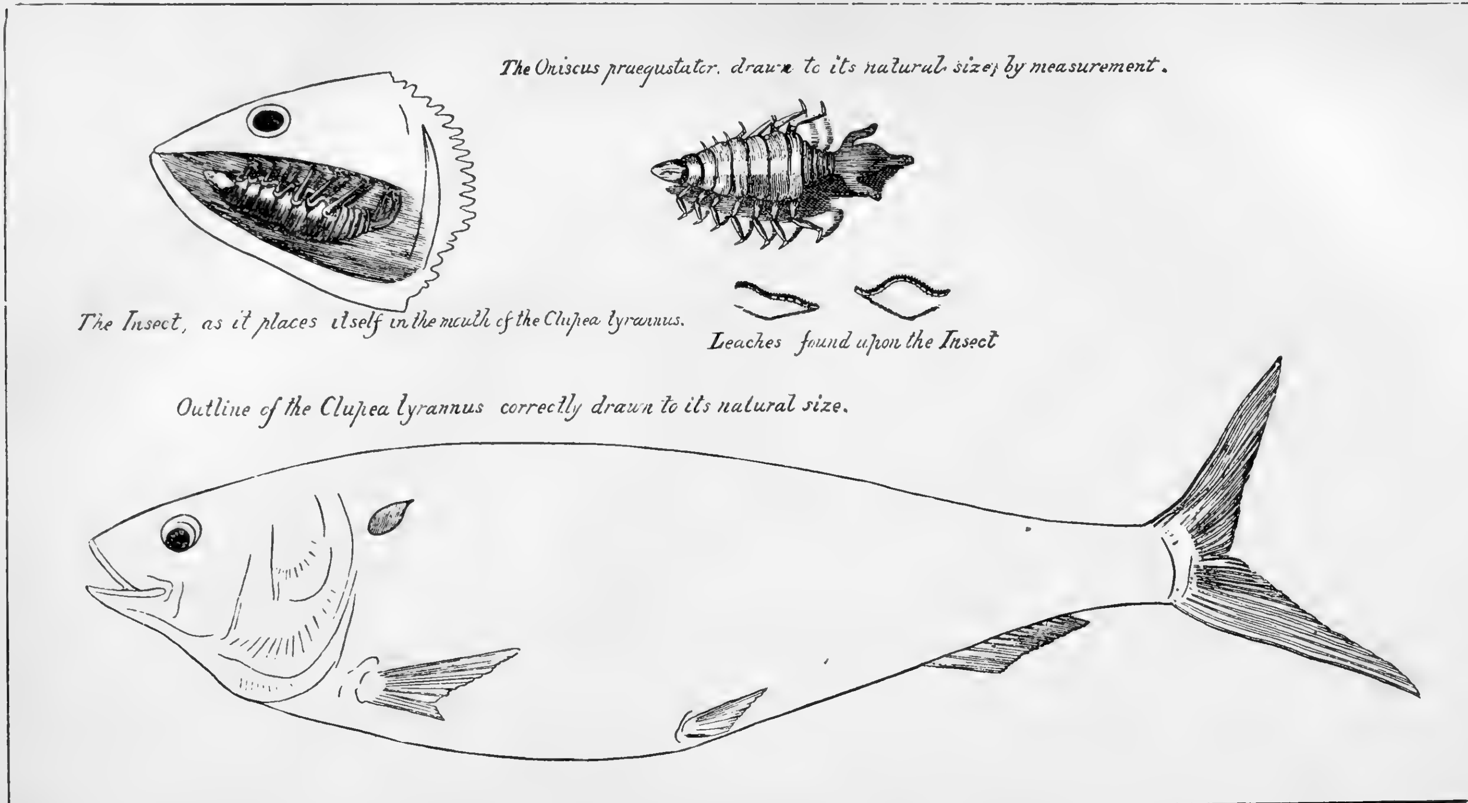


Fig. 10.



Facsimile of plate accompanying Latrobe's description of Clupea tyrannus and Oniscus praegustator.

Fig. 11.

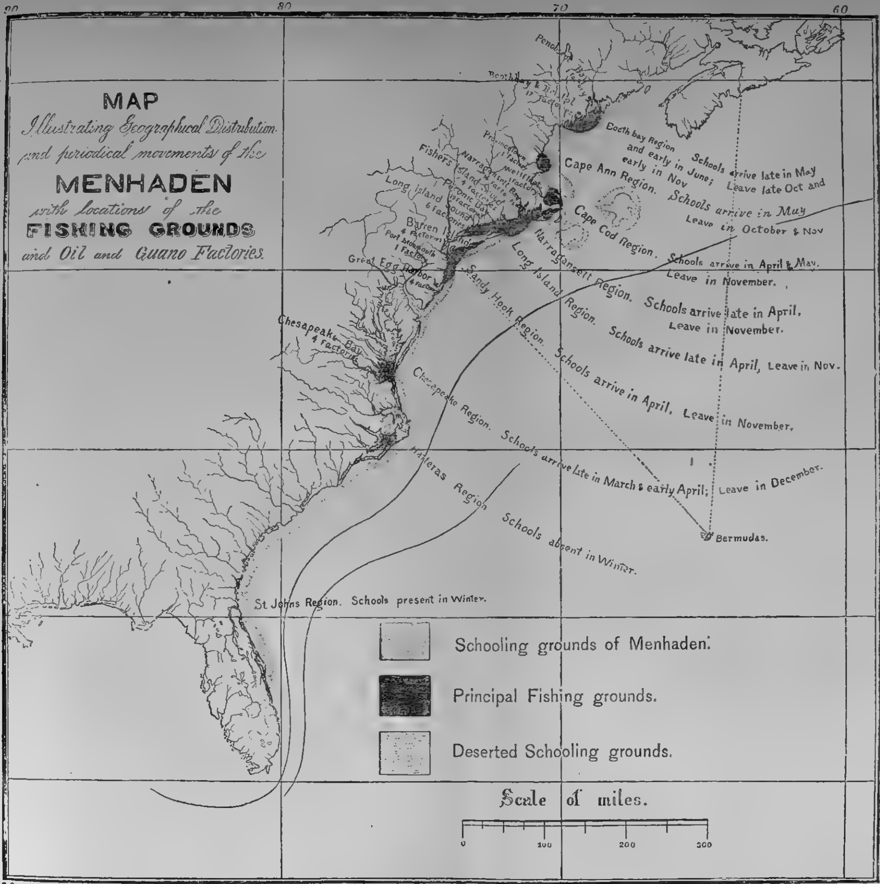

MAP
Illustrating Geographical Distribution and periodical movements of the
MENHADEN
with locations of the
FISHING GROUNDS
and Oil and Guano Factories.
Boothbay Region. Schools arrive late in May and early in June; Leave late Oct and early in Nov
Cape Ann Region. Schools arrive in May Leave in October & Nov
Cape Cod Region. Schools arrive in April & May. Leave in November.
Narragansett Region. Schools arrive late in April. Leave in November.
Long Island Region. Schools arrive late in April, Leave in Nov.
Sandy Hook Region. Schools arrive in April. Leave in November.
Chesapeake Region. Schools arrive late in March & early April; Leave in December.
Hatteras Region Schools absent in Winter.
St Johns Region. Schools present in Winter.
Bermudas.
Fishers Island Sound
Narragansett Bay
Long Island
Peconic Bay
6 Factories
Barren Island
4 Factories
Port Monmouth
1 Factory
Great Egg Harbor
Chesapeake Bay
4 Factories
Schooling grounds of Menhaden.
Principal Fishing grounds.
Deserted Schooling grounds.
Scale of miles.
0
100
200
300
90
80
70
60
45
40
35
30
25

Fig. 12.

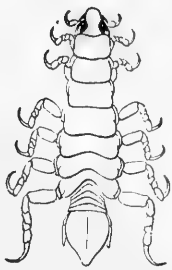


Fig. 14.

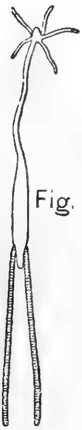


Fig. 15.

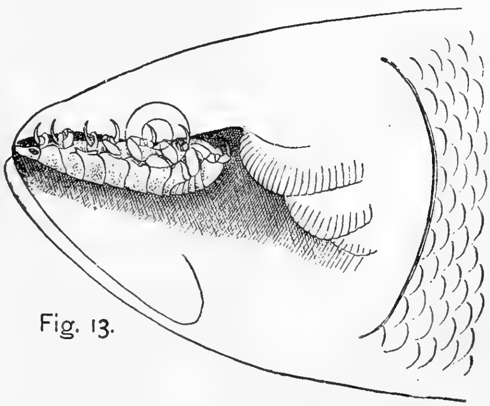


Fig. 13.

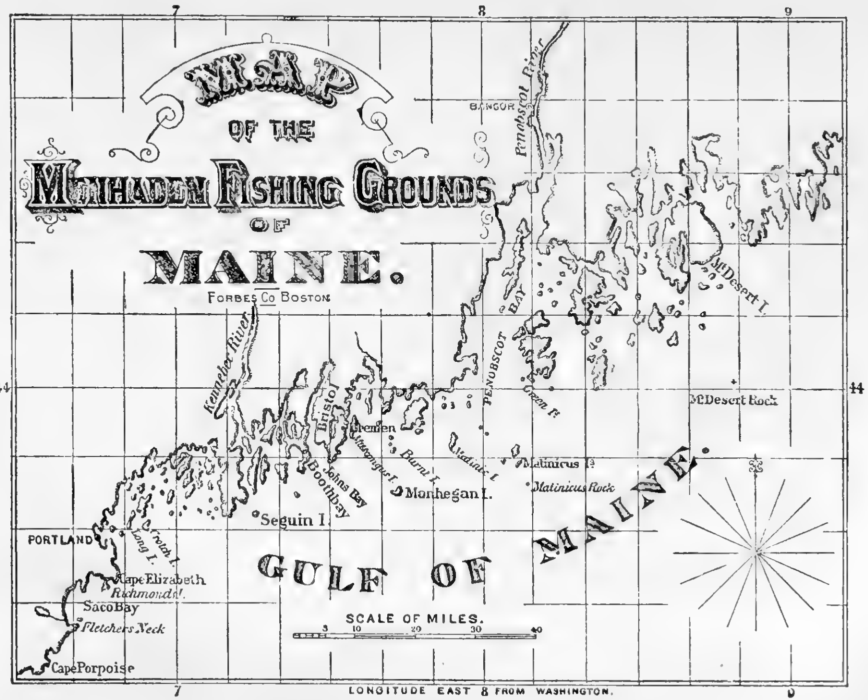
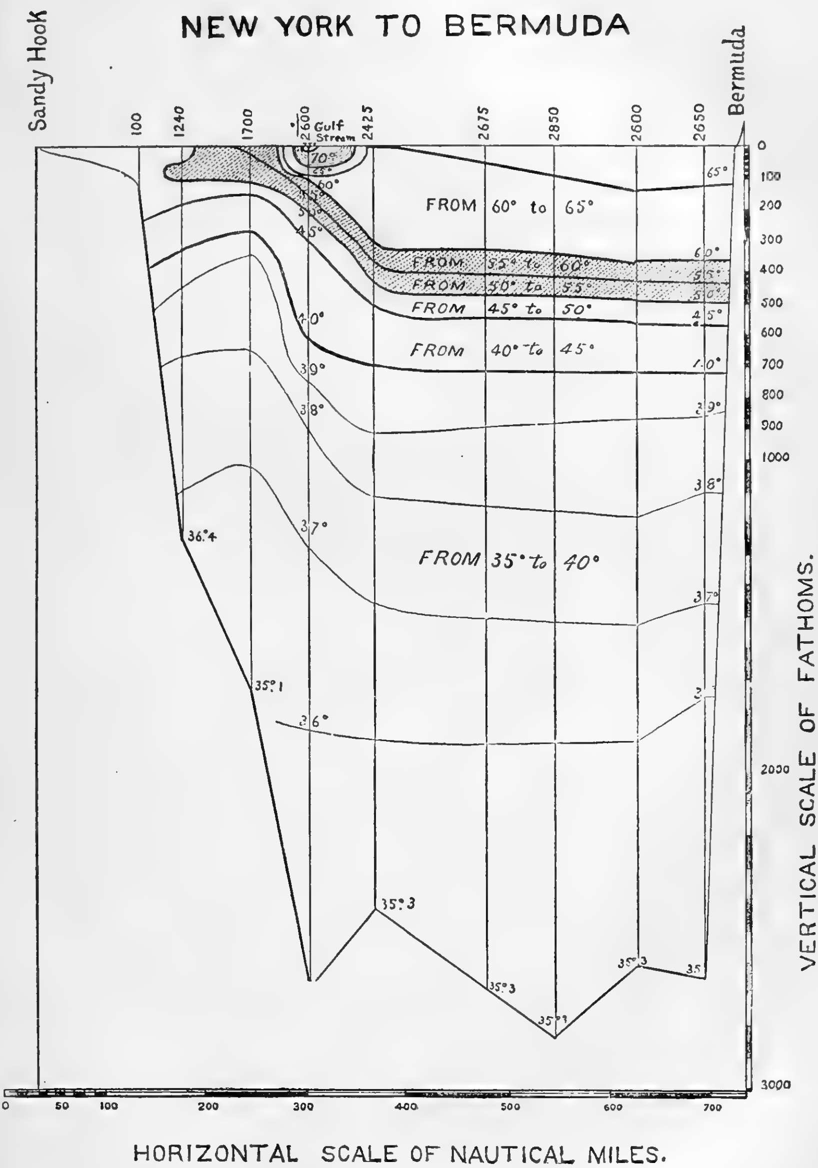
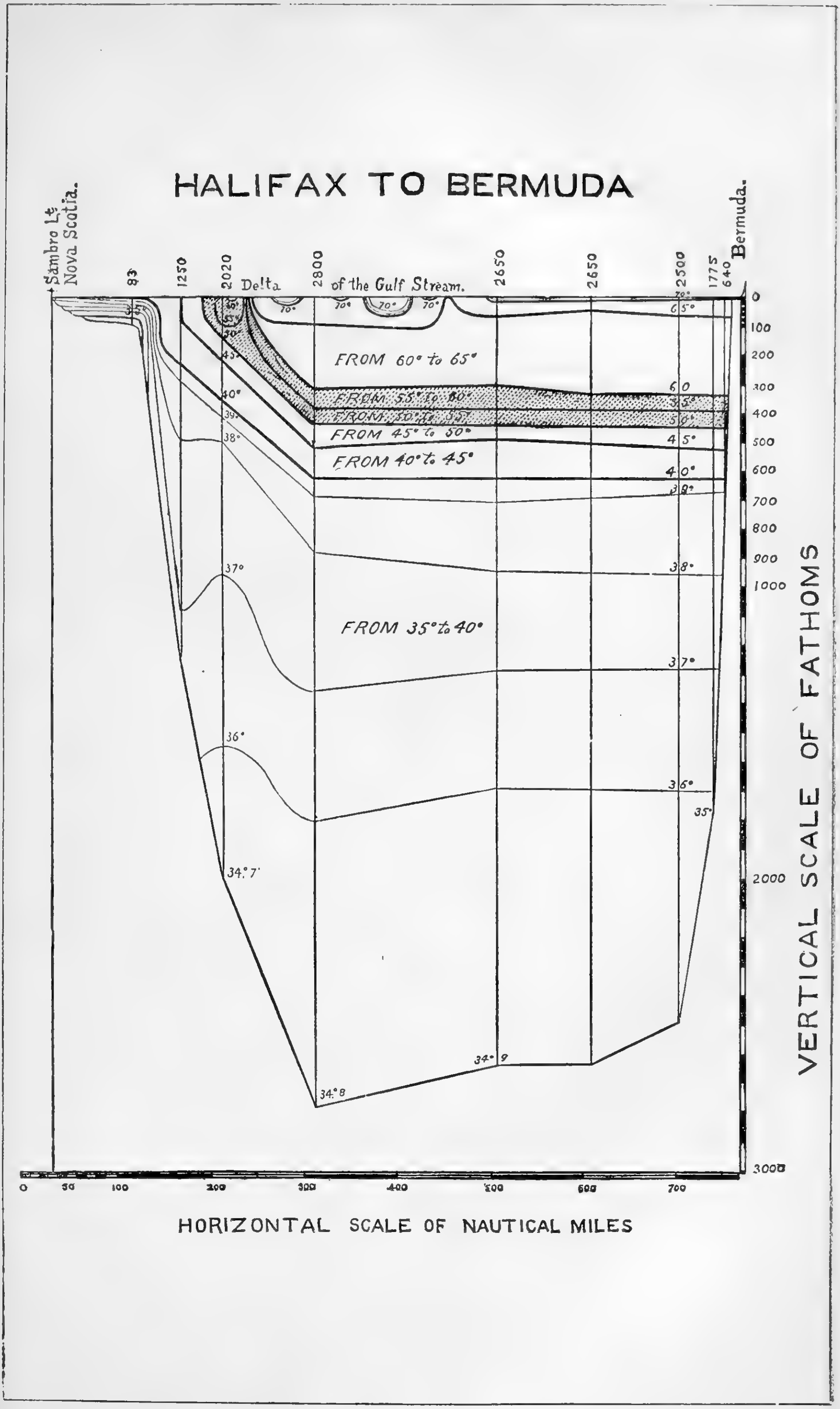

MAP
OF THE
MENHADEN FISHING GROUNDS
OF
MAINE.
FORBES CO BOSTON
BANGOR
Penobscot River
Kennebec River
PENOBSCOT BAY
Green I.
Mt Desert I.
Mt Desert Rock
Bristol
Bremen
Burnt I.
Matinicus I.
Matinicus Rock
Johns Bay
Boothbay
Monhegan I.
Seguin I.
PORTLAND
Crotch I.
Long I.
Cape Elizabeth
Richmonds I.
Saco Bay
Fletchers Neck
Cape Porpoise
GULF OF MAINE.
SCALE OF MILES.
LONGITUDE EAST 8 FROM WASHINGTON.

Fig. 16.


NEW YORK TO BERMUDA
Sandy Hook
Bermuda
100
1240
1700
2600
Gulf Stream
2425
2675
2850
2600
2650
70°
60°
65°
55°
50°
45°
40°
39°
38°
37°
36°
36°.4
35°.1
35°.3
FROM 60° to 65°
FROM 55° to 60°
FROM 50° to 55°
FROM 45° to 50°
FROM 40° to 45°
FROM 35° to 40°
0
100
200
300
400
500
600
700
800
900
1000
2000
3000
VERTICAL SCALE OF FATHOMS.
0
50
100
200
300
400
500
600
700
HORIZONTAL SCALE OF NAUTICAL MILES.


HALIFAX TO BERMUDA
Sambro Lt. Nova Scotia.
Bermuda.
83
1250
2020
2800
2650
2650
2500
1775
640
Delta of the Gulf Stream.
70°
FROM 60° to 65°
FROM 55° to 60°
FROM 50° to 55°
FROM 45° to 50°
FROM 40° to 45°
FROM 35° to 40°
65°
60
55°
50°
45°
40°
39°
38°
37°
36°
35°
34.°7
34.°8
34.°9
0
100
200
300
400
500
600
700
800
900
1000
2000
3000
50
100
200
300
400
500
600
700
VERTICAL SCALE OF FATHOMS
HORIZONTAL SCALE OF NAUTICAL MILES

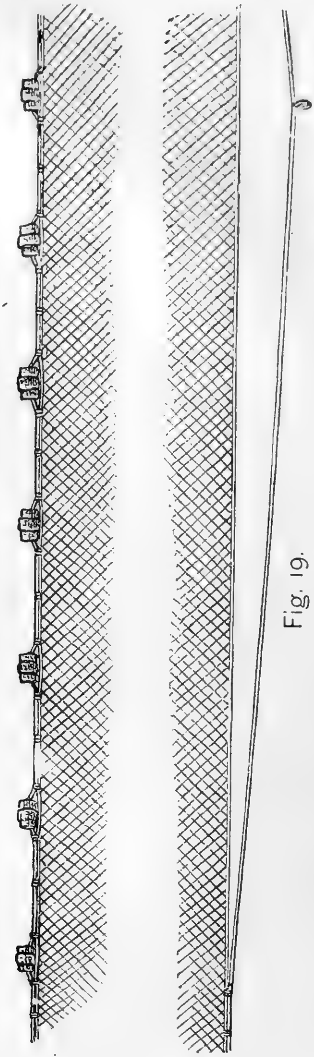


Fig. 19.

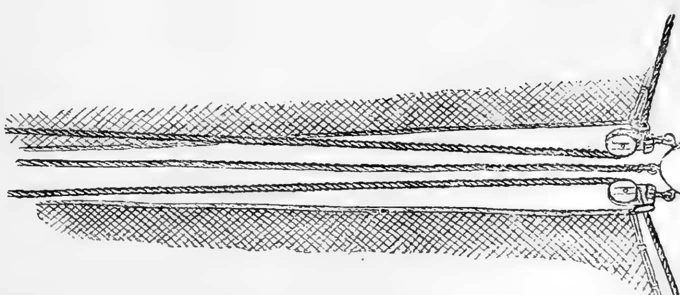


Fig. 20.

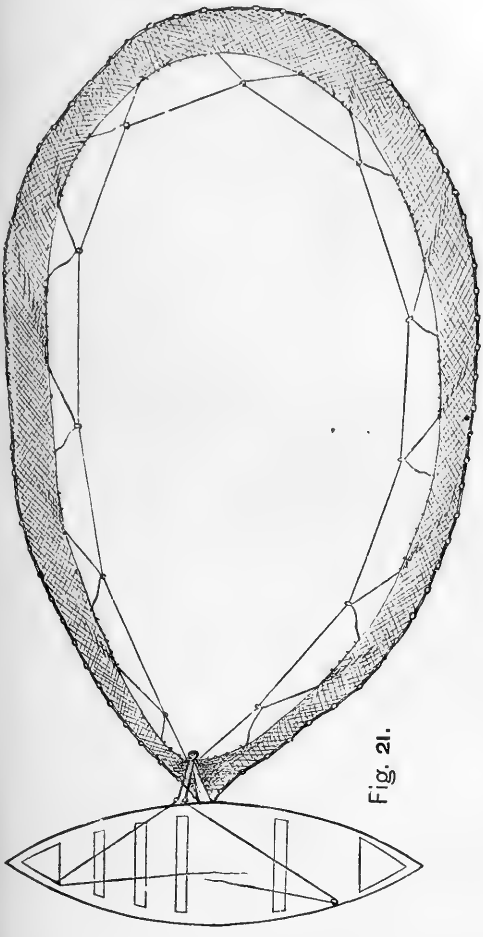


Fig. 21.

Plate XV.

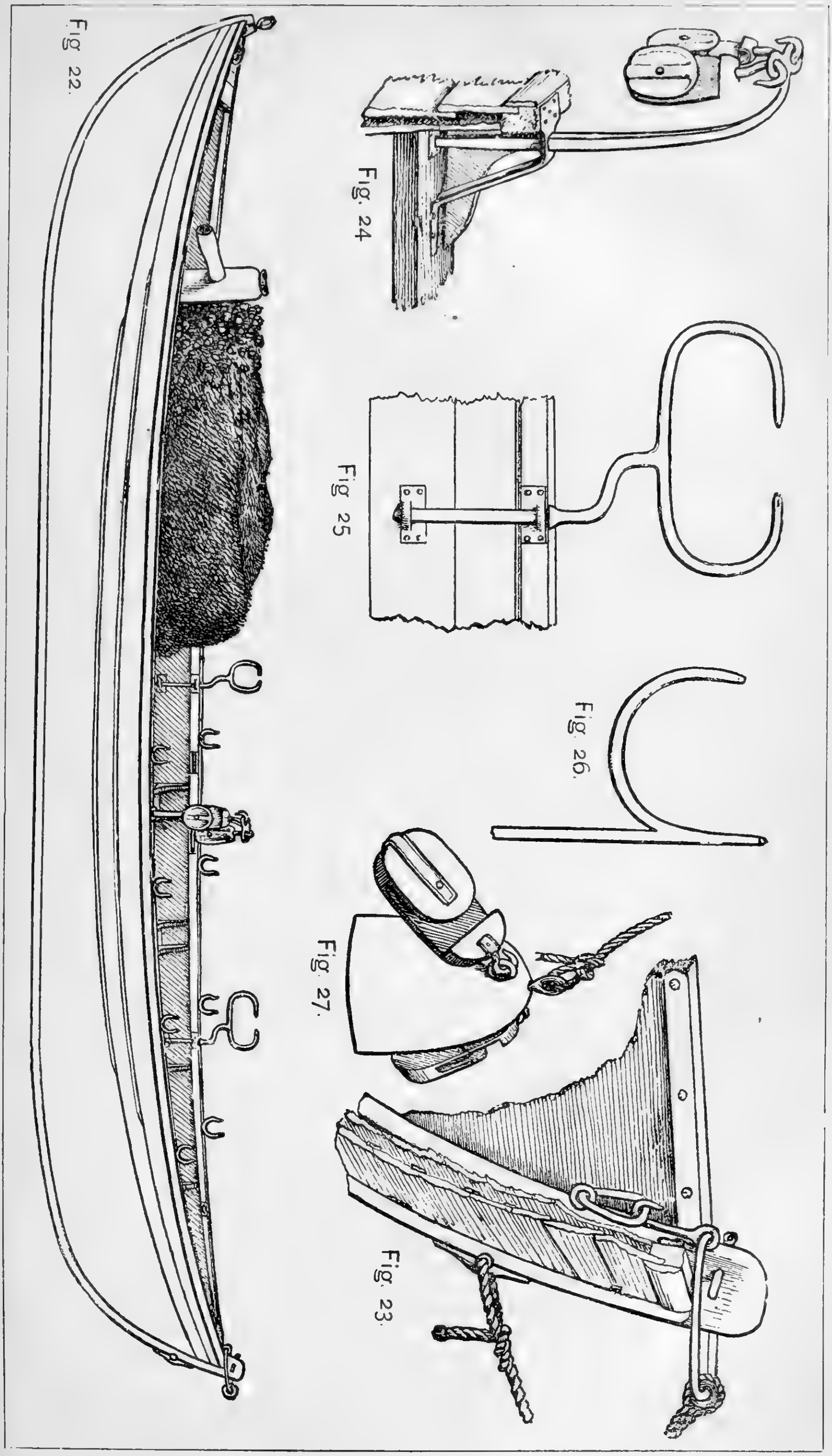


Fig 22.

Fig. 23.

Fig. 24

Fig 25

Fig. 26.

Fig. 27.

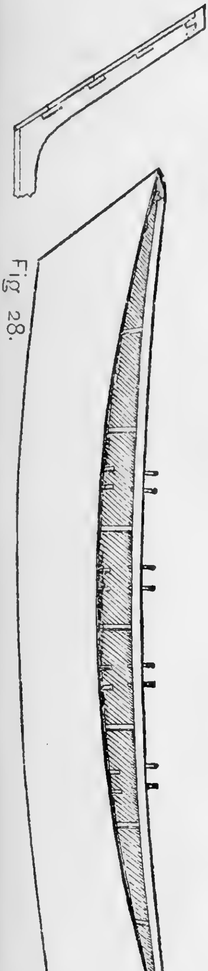


Fig 28.

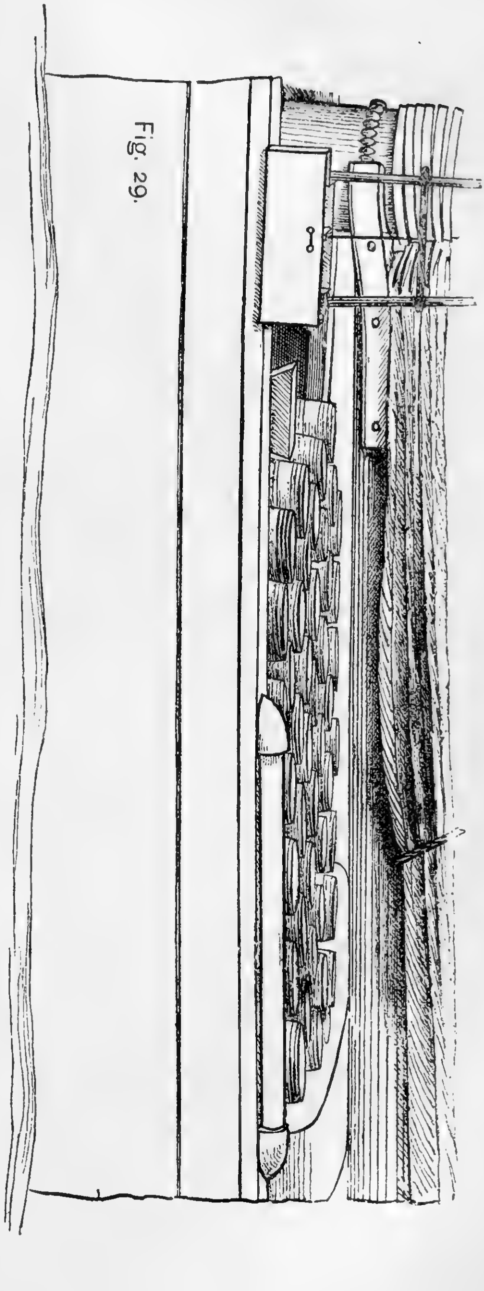


Fig. 29.

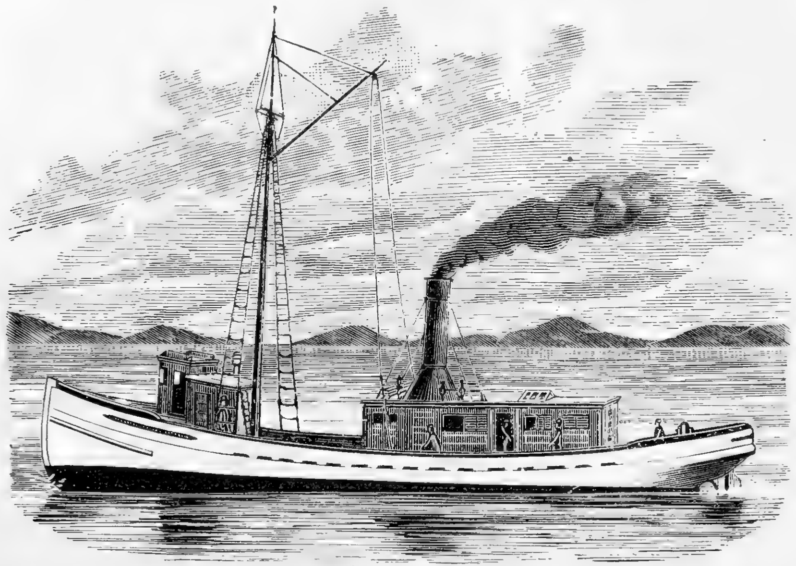


Fig. 30. A MENHADEN FISHING STEAMER.

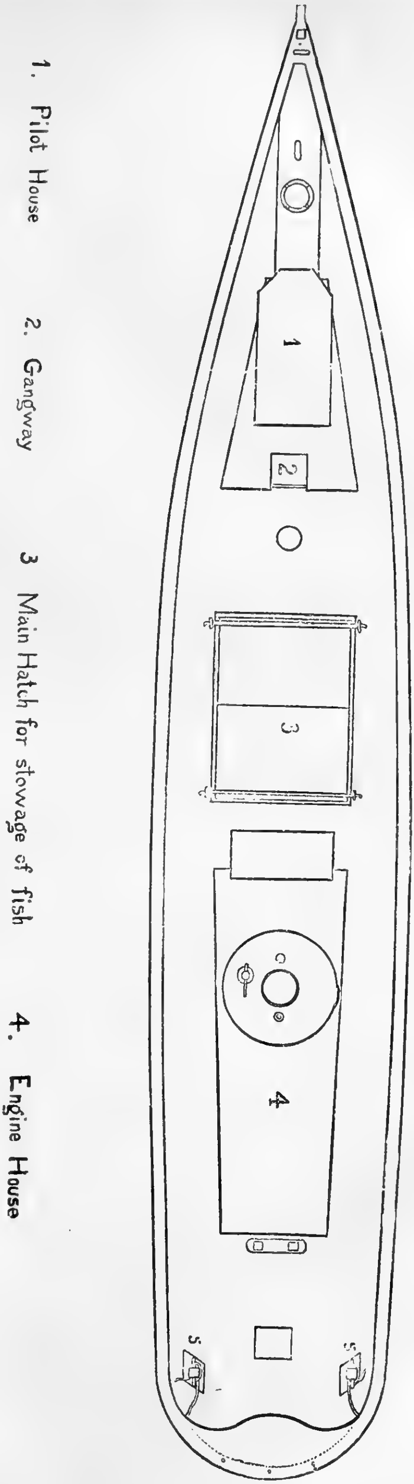

1. Pilot House
2. Gangway
3 Main Hatch for stowage of fish
4. Engine House
5. Towing Chocks.
1
2
3
4
5
5

Fig. 31.

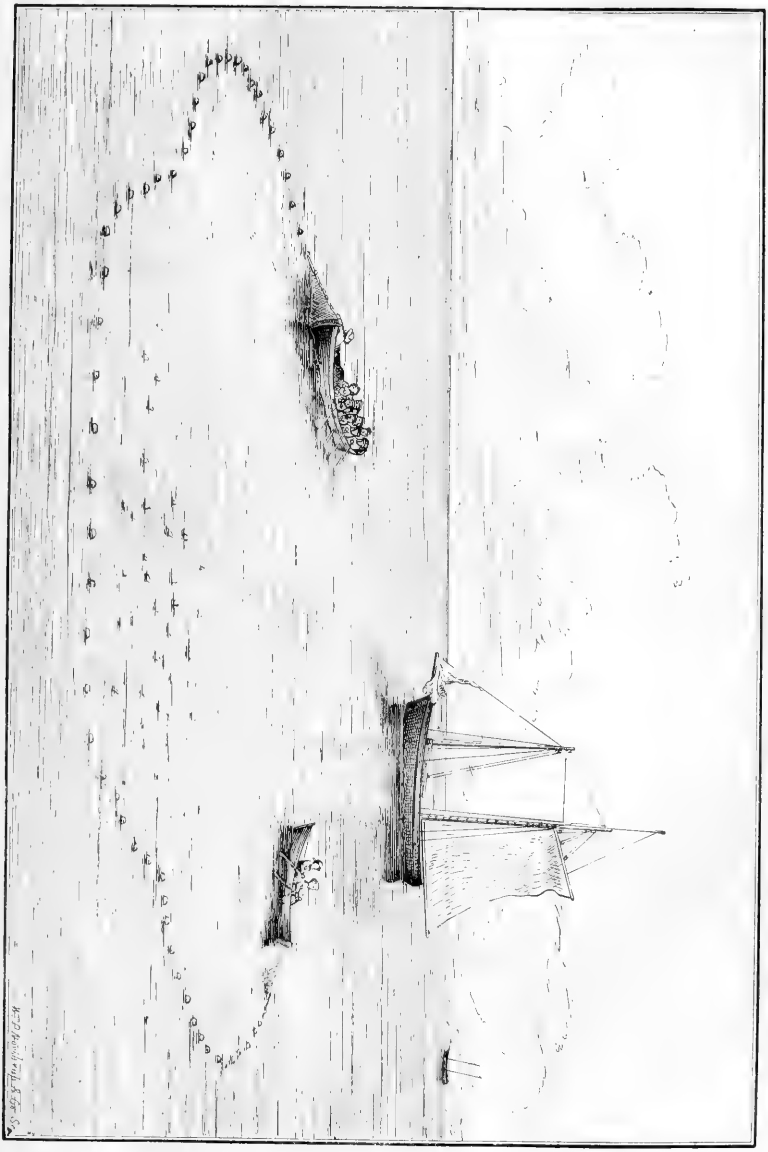


Fig. 32.

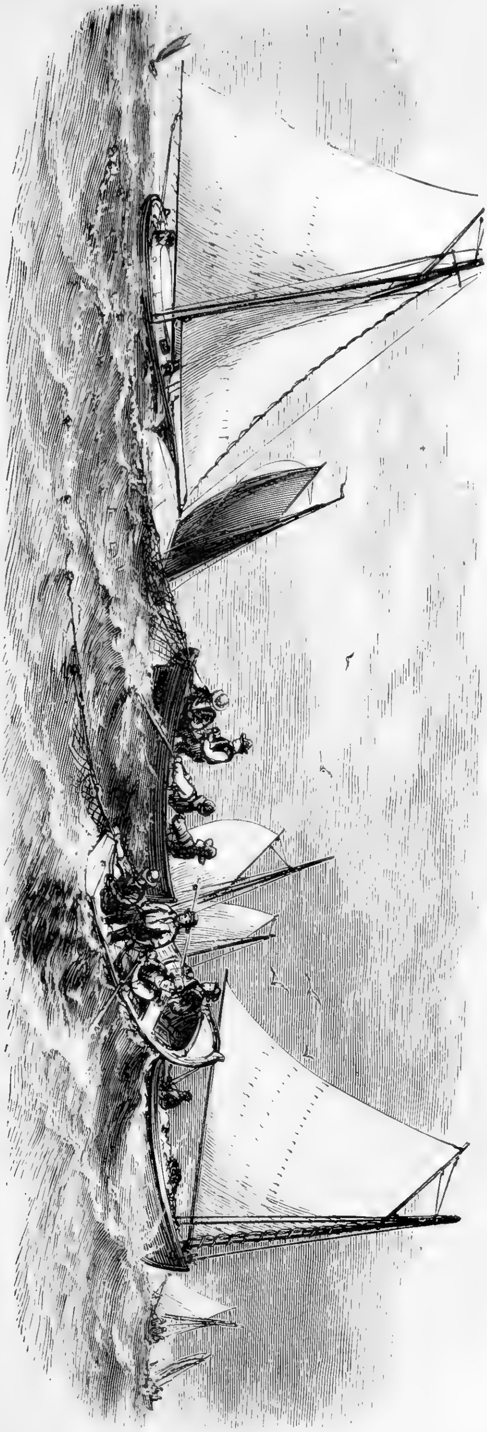


Fig. 33.

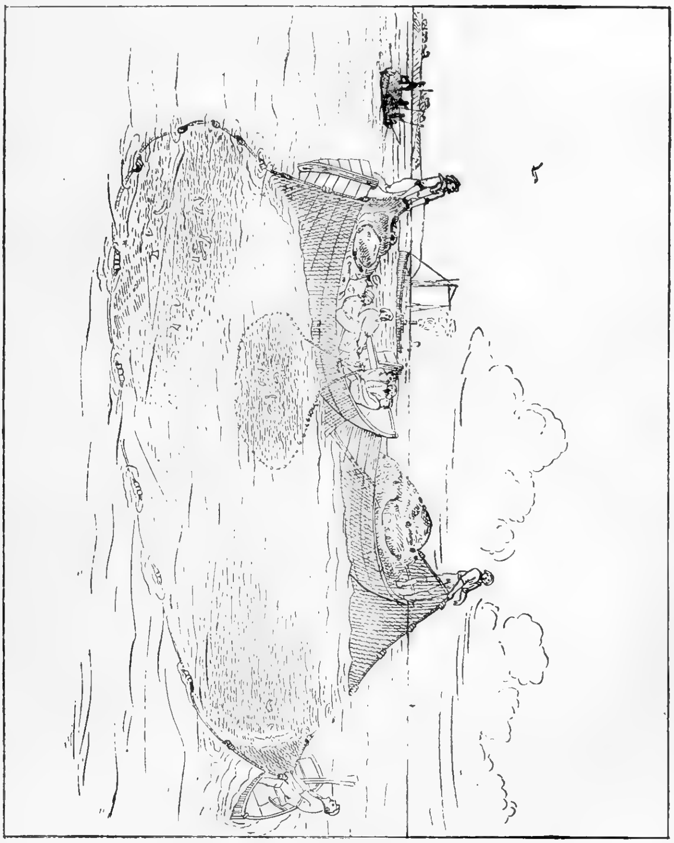


Fig. 34.

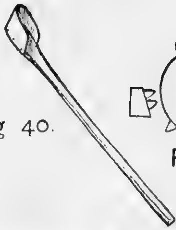


Fig 40.

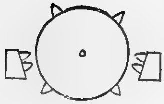


Fig 38

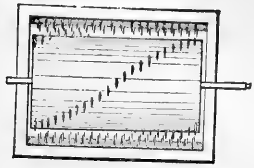


Fig 37

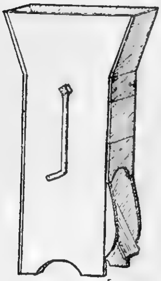


Fig. 36

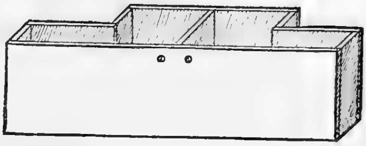


Fig 39.

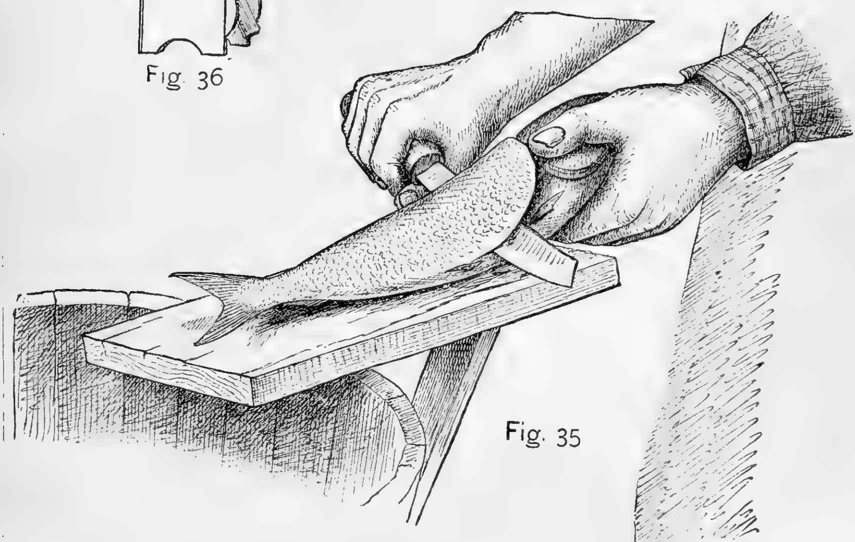


Fig. 35

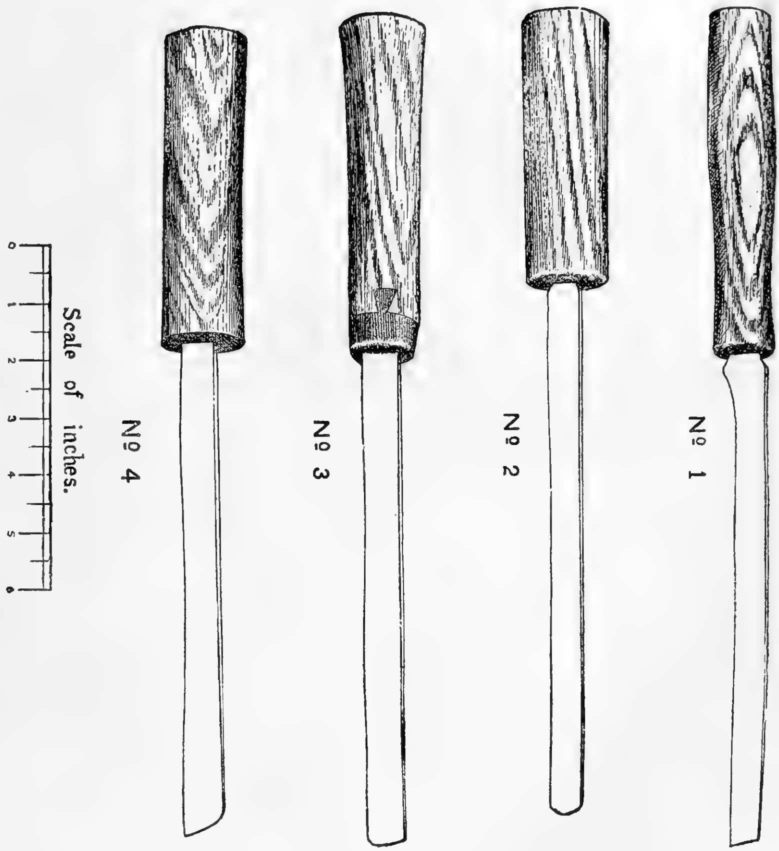


Fig. 41.

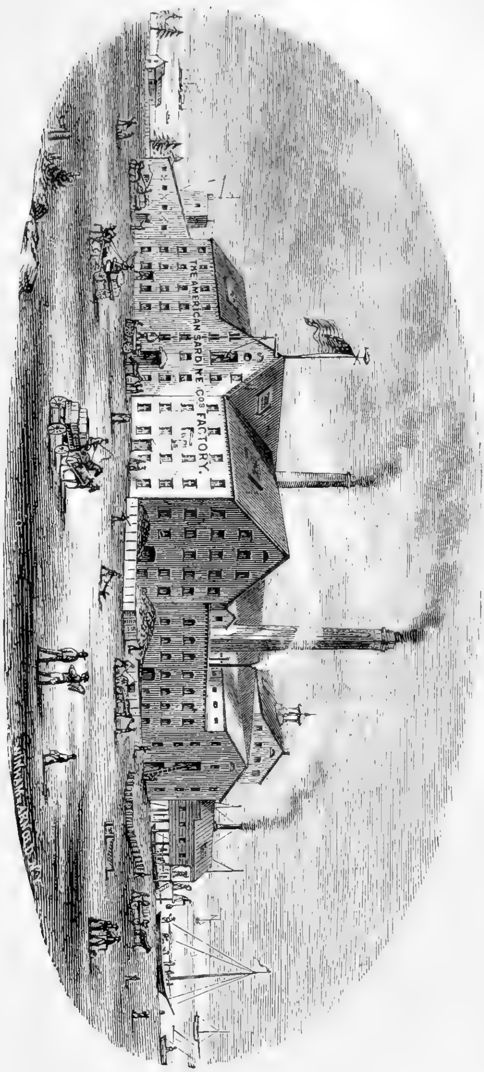


Fig. 42.

Plate XXV.

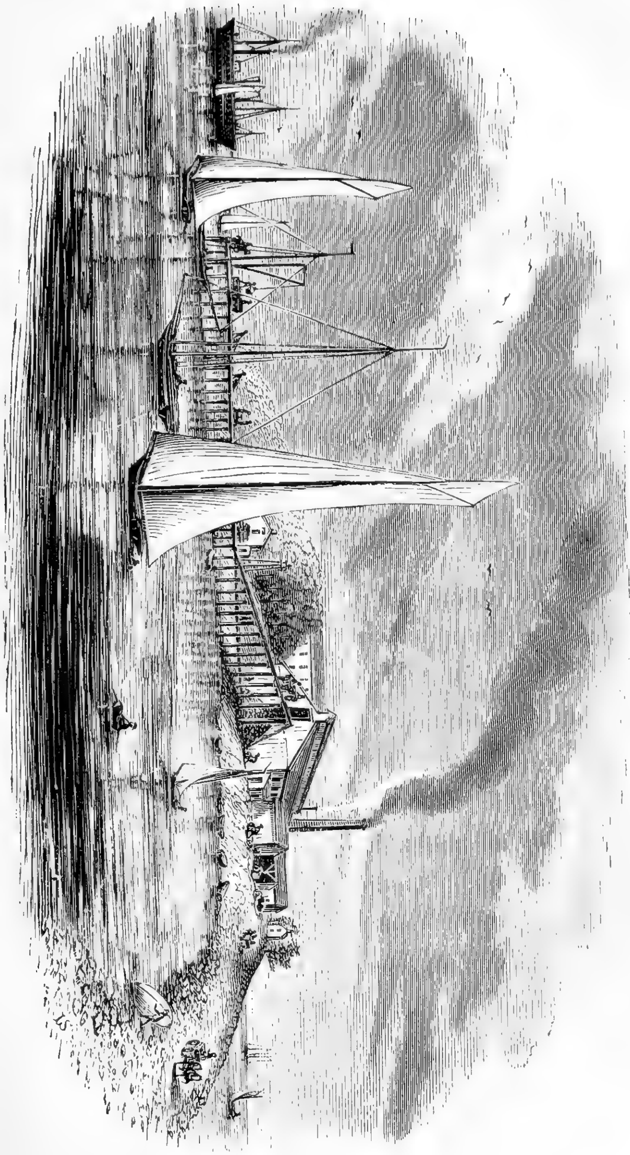


Fig. 43.

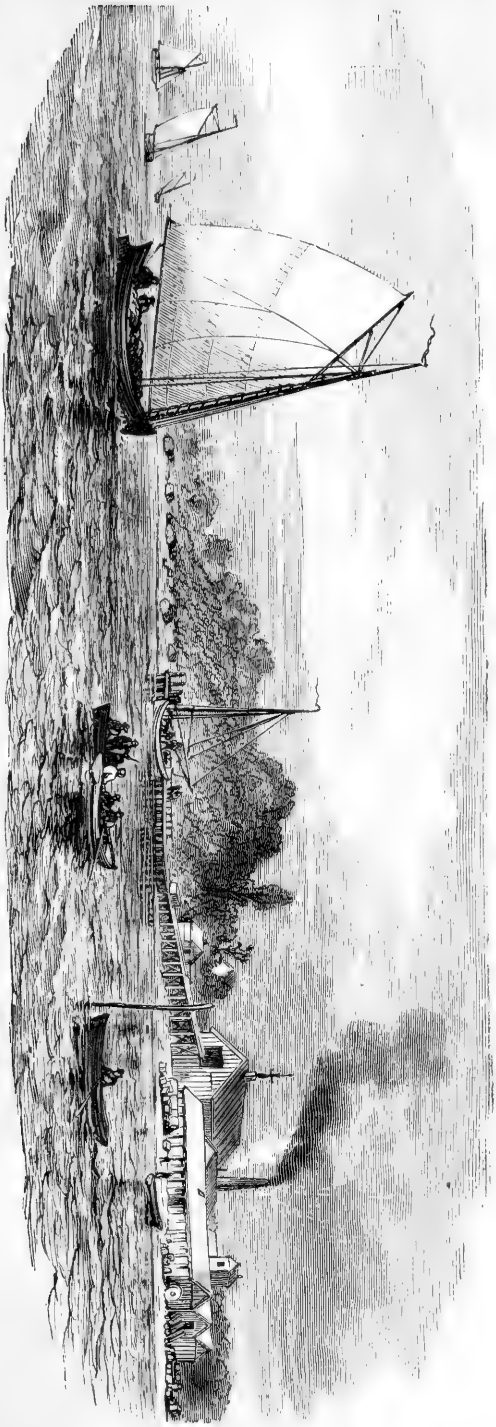


Fig. 44.

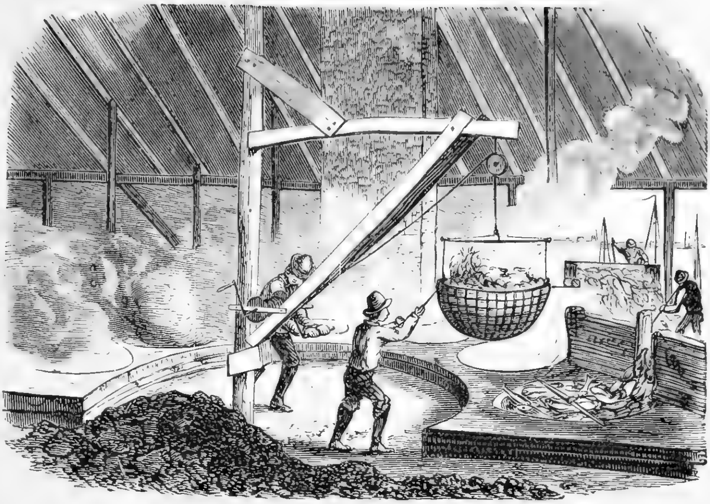


Fig. 45.

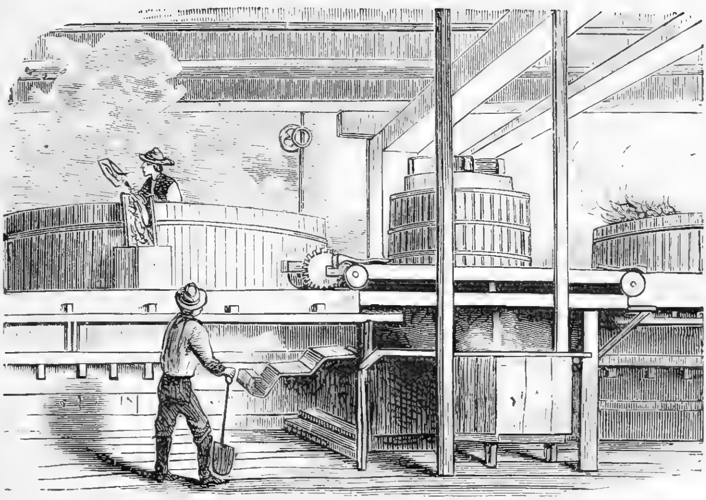


Fig. 46.

Plate XXVIII.

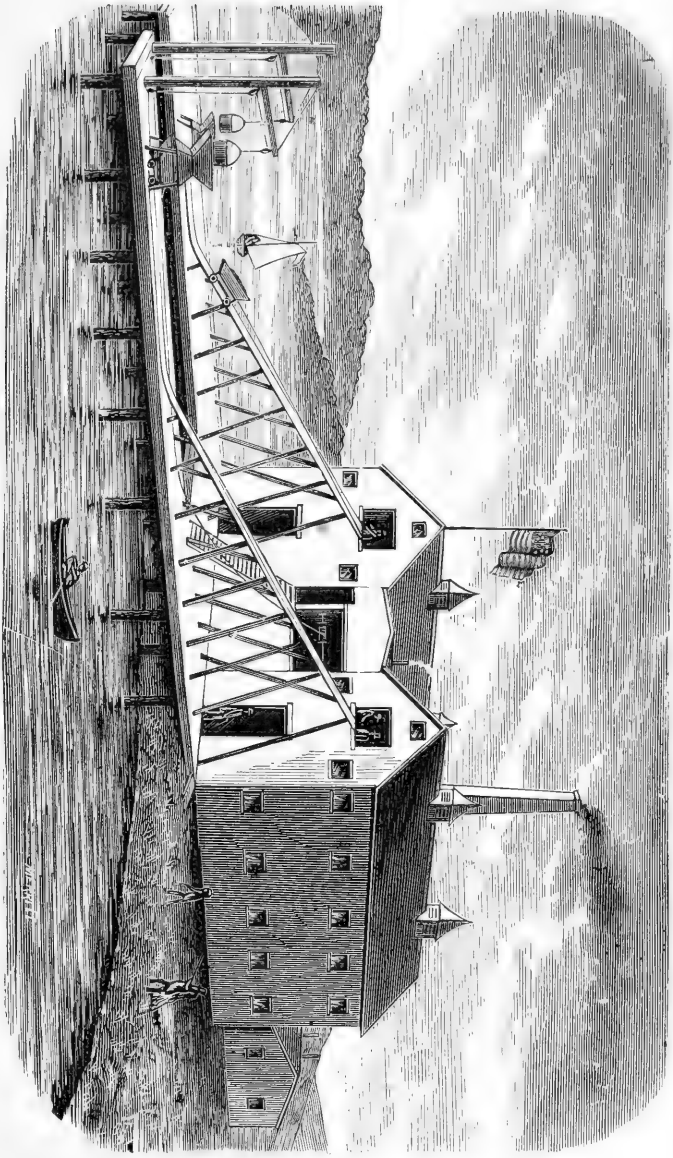


Fig. 47.

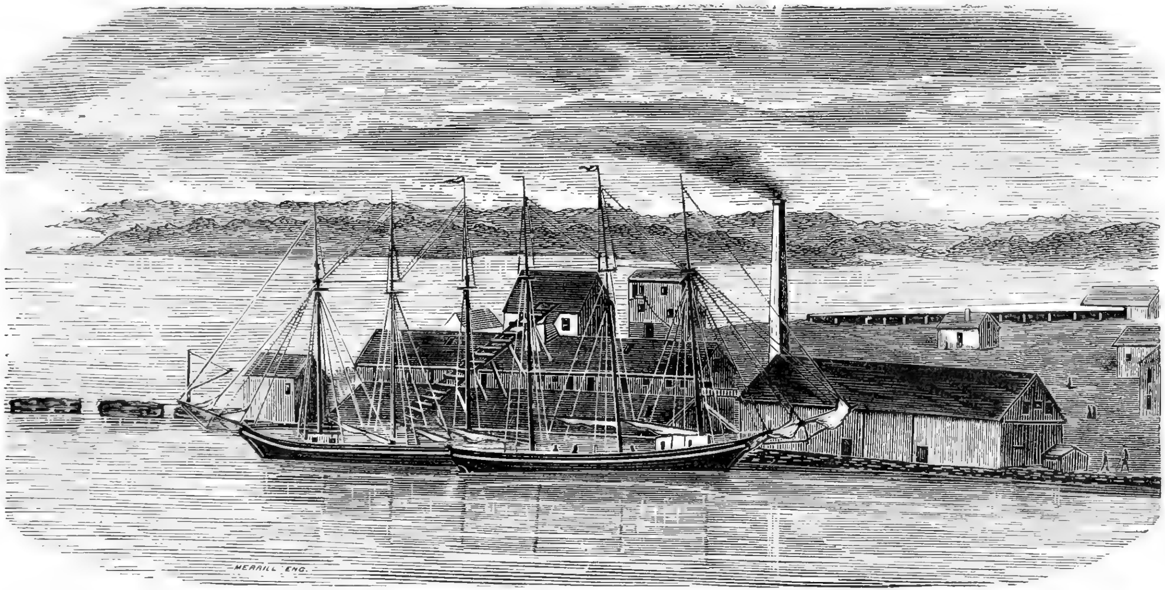


Fig. 48. J. CHURCH & CO.'S FACTORY, BRISTOL.

Plate XXX.

CANCELLED.

Plate XXXI.

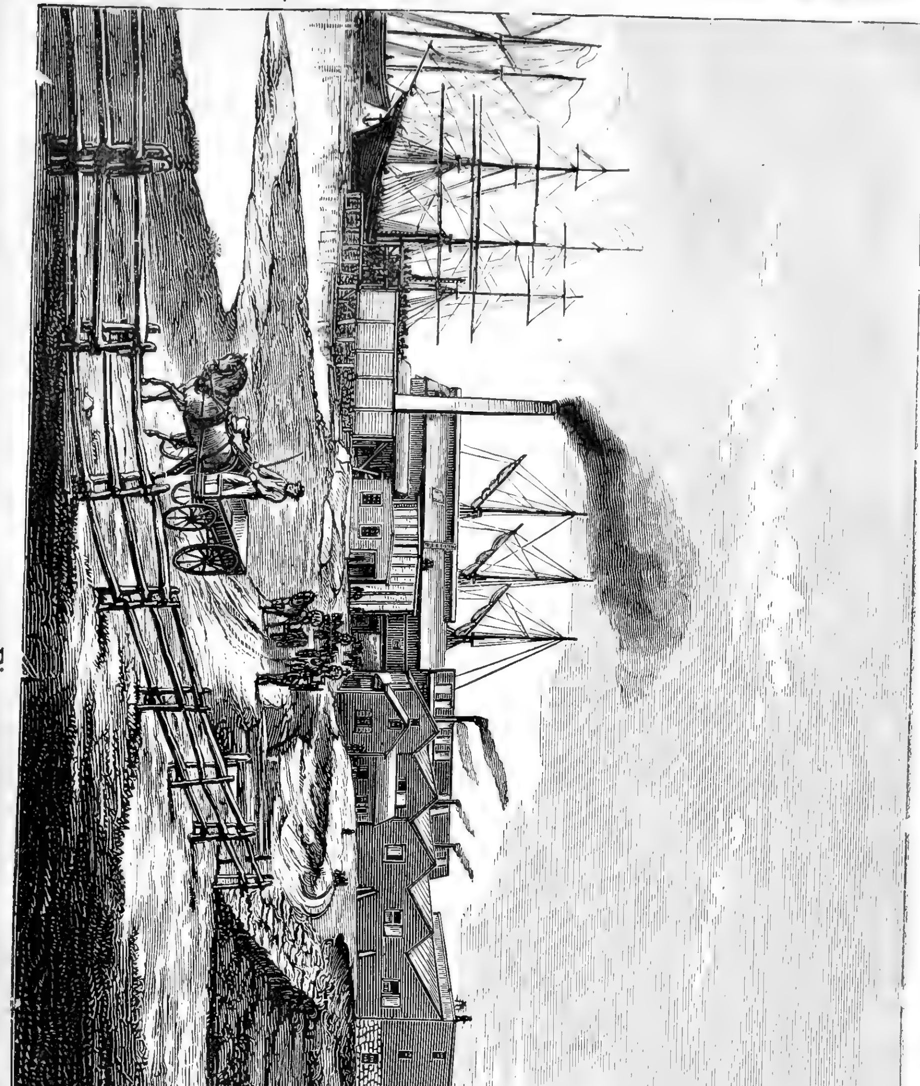


Fig. 50.

II.—GEOGRAPHICAL DISTRIBUTION OF THE GADIDÆ OR THE COD FAMILY, IN ITS RELATION TO FISHERIES AND COMMERCE.

By Karl Dambeck.*

A.—CHARACTERISTICS OF THE GADIDÆ.

Next to the herring, the cod is perhaps the best known and most important family of fishes, on account of its extended and very productive fisheries and commerce. The study of its characteristics and general distribution, however, is not only interesting to the fisher and business man, but also to the naturalist, on account of their bearing upon the relations existing between currents, temperature, saltness, and depth of the ocean; the modes of distribution of animal and vegetable life, and many other unsolved problems. According to the careful and reliable investigations of Dr. Albert Günther, of the British Museum, the family comprises 22 genera, 60 species, and numerous varieties. Of these, 9 genera, with 41 species and several varieties, are especially important, viz: *Gadus*, with 19 species; *Merlucius*, with 3; *Phycis*, with 5; *Molva*, with 3; *Motella*, with 5; *Brosmius*, with 2; *Couchia*, with 3, and *Raniceps* and *Lota*, with 1 species each, while the other 13 genera, with their 19 species, are simply connecting and transitional forms in this large series of widely-distributed fish, and are far less numerous in individuals as well as in species. The fertility appears to decrease in the individual in proportion to this multiplicity of genera and species. We may, for instance, find with the ling and the cod three to nine

* Gaea, 1877, III, pp. 158, 224, 345, 422.—Revised by Tarleton H. Bean.—Dambeck's paper is compiled from various sources, some of them antiquated, and, consequently, containing no reference to recent discoveries. Many statements offered as facts are untrue, and others doubtful. Some generalizations are made from insufficient data, some are entirely founded on error. After making due allowance for misstatements and conclusions of uncertain value, there still remains much that is interesting. The nomenclature which he accepts differs from that adopted by many American authors, hence a brief synonomy is given:

Lota vulgaris (*maculosa*) = *Lota maculosa*, (Le S.) Rich.
Lota vulgaris = *Lota maculosa* var. *vulgaris*, Jenyns.
Gadus morrhua-callarias = *Gadus morrhua*, L.
Gadus æglefinus = *Melanogrammus æglefinus*, (L.) Gill.
Gadus virens = *Pollachius carbonarius*, (L.) Bon.
Gadus tomcodus = *Microgadus tomcodus*, (Walb.) Gill.
Couchia argentata = *Ciliata argentata*, (Reinh.) Gill.
Phycis regalis = *Urophycis regius*, (Walb.) Gill.
Phycis americanus = *Phycis chuss*, (Walb.) Gill.
Gadus californicus = *Microgadus proximus*, (Grd.) Gill.
Brosmius vulgaris = *Brosmius brosme*, (Fabr.) White.

millions of fully-developed eggs, while *Lotella* and *Halargyreus* have only a few thousand.

The cod family has a remarkable tendency to variation, as is most strikingly apparent in the difficulty of defining genera and species; the species show many varieties (*Gadus morrhua*, near Great Britain, has two, a light-colored one in the north and a dark one in the south), the genera, numerous species, &c., throughout the whole family. The caudal or tail fin is never placed at the end of the terminal vertebra, but has its lower portion slightly in front of it, and even unites sometimes with the anal fin; the scales are frequently ctenoidal,* and thus also similar to those of the fishes of former ages. Sometimes the eyes are very large, which is usually considered as peculiar to the more recent forms of fishes, as the number of barbels also is most probably an indication of the stage of development, increasing or diminishing with the antiquity of the fish. The head is often comparatively small, as with *Brosmius vulgaris;* often large, as with *Gadus macrocephalus*, and sometimes the lower jaw is elongated and hook-shaped—a mark of antiquity, according to the analogy of the salmon. I therefore conclude that the family is still in the process of development, namely, from fresh-water into salt-water fish. I do not assert, however, that the saltness of the ocean is greater at present than in former ages, but I wish to state the fact that the codfish, *Gadidæ*, also at previous periods lived in regions of the sea where the water was but slightly salt; for in the present time, too, they live more particularly in fresh and brackish water, or in sea-water of not more than 2 to 3 per cent. of salt.†

The *Lota vulgaris* is a true fresh-water fish in the lakes and rivers of Central, Northern, and Eastern Europe, Northern Asia, and northern North America, and yet, according to Pallas, it also occurs in the Arctic Ocean, on the coast of Siberia, as far as Indigirka, and according to Rathké in the Black Sea, and according to Yarrell in the Frith of Forth. Others live in the open ocean, but their old habit drives them into the rivers again. Thus the cod migrates up the Tweed. The *Gadus macrocephalus*, according to Pallas, frequents the ocean around Kamtschatka and America, but ascends the rivers in May and returns to the ocean in August and September, after remaining about four months in fresh water.

They all live in regions of the sea where the water contains but little salt, especially at the mouths of rivers, fresh-water basins, ports, &c. They require a temperature of the water of from 39° to 44°; the *Lota vulgaris* can endure a somewhat lower temperature, and the southern forms, *Physiculus* and *Uraleptus*, will bear a somewhat higher; thus the family belongs to the temperate zone, and its occurrence indicates unmistakably a medium temperature, even where such might not be

* The gadoids, as now limited, all have cycloid scales.—T. H. B.

† *Microgadus tomcodus* has been transferred suddenly from salt water to a fresh-water aquarium and kept alive for months.—T. H. B.

expected, whether it be in the arctic or tropical regions.* At spawning time, when the northern forms develop greater vital activity and possess a higher temperature of the blood, they seek for water of from 35° to 37°, as it may be found in February and March upon the southern coast of Spitzbergen, at the Loffoden Islands, in the fiords of Finmark, and at the Faroes, in May and June on the Banks of Newfoundland, Gulf of St. Lawrence, and Labrador; the southern forms, however, are smaller and less lively, and live in uniform temperature; they, therefore, only migrate at spawning time to the near coast, but usually from water of considerable depth. The former migrate in a horizontal direction; the latter in a vertical one. The *Gadidæ*, then, are fresh-water and migratory fish. They are voracious, and subsist upon marine vegetation as well as upon animals; they are omnivorous, and consequently readily adapt themselves to their surroundings.

Professor Mœbius found in the stomach of *Gadus morrhua*, L., large pieces of *Ulva lactaca* and *Zostera marina*, two marine plants, besides shells, snails, crabs, and fishes. The above-mentioned variations in color generally indicate differences in depths at which they live, and comprise white, yellowish, brown, speckled, green, and black.† Every species, it is true, lives at different depths at different seasons, but all are capable of living at considerable depth, even the fresh-water species, some of which inhabit fresh water at considerable elevations, especially in Europe. This fact seems also to prove their fresh-water origin, as does the size of their gill openings, which enables them to absorb the requisite amount of oxygen from the deep fresh water, always less rich in that element than salt or surface water. Therefore, in seeking after fresh water and deep water they are perfectly in accordance with their habits.

The following tables will show the depths and elevations at which the *Gadidæ* live, as well as the temperature of the water, and the proportions of salt contained in it:

Names of species.	Locality.		Elevation and depth.		Temperature.	Proportion of salt.
			Feet.			*Per cent.*
Lota vulgaris	The Alps, Lake of St. Maritz	These lakes are 180 to 240 ft. in depth.	5,580	Elevation.		
Do	Switzerland, Lake of Seelisberg		2,240			
Do	Lake Garda		213			
Gadus morrhua	Baltic Sea, Stollesgrund		42	Depth.	4–5° C.	1.44
Do	Baltic Sea, Benehanen		300			0.80
Do	Baltic Sea, Dalaroe		240			0.75
Do	Newfoundland		360			
Phycis blennioides	North Sea		300			
Gadus merlangus	Skagerak, Arendal		360			3.60
Molva vulgaris	European coasts		600			3.64
Gadus minutus	Mediterranean		1,000			
Phycis mediterraneus	Mediterranean, Sicily		1,200			
Halargyreus Johnsonii	Atlantic, Madeira		1,800			
Chiasmodus niger	Atlantic, Madeira		1,872			

* *Gadus morrhua* has been taken by the United States Fish Commission in from 34° to 46° F. *Lota maculosa* endures a much higher temperature in the Connecticut River, the Ohio, and the Missouri.—B.

† Variations in color coincide with changes in the colors of surrounding objects upon the feeding-grounds.—B.

B.—GENERAL DISTRIBUTION.

As to their general distribution, they occupy a portion of the frigid zone, but preferably the temperate zone of the northern hemisphere, especially the Arctic, Northern Atlantic, and Northern Pacific Oceans, as well as the fresh waters of northern North America, Europe, and Asia. They occur, however, sporadically in the torrid zone, and southern hemisphere. Individuals are most numerous on the coasts of Newfoundland, Nova Scotia, and Labrador, and in the neighborhood of the Loffoden Islands, Norway, Finmark, Iceland, the Faroe, and British Islands, that is, on the coasts of both continents, and on the line where the Arctic and North Atlantic Oceans meet. This region may therefore be named the domain of the *Gadidæ*, and to it belong particularly the 9 genera of the above tables, with 41 species; the other 13 genera, with 19 species, belong to the southern temperate and torrid zone, and to the Pacific and Indian Oceans, viz, the extreme limits of the domain. Whether these latter are the remnant of a southern *Gadidæ* fauna, or are simply straying members from the northern one is difficult to decide, but most probably the latter is the case. The northernmost limit is in general 77° north latitude, and the southernmost, in the Atlantic, 30° north latitude. The middle region, therefore, between 45° and 62° north latitude, stretches from Newfoundland to Great Britain and Scandinavia. In the Pacific Ocean the boundary runs from Northern China, at Chusan, northward along the west coast of Japan and the Kurile Islands to the southern extremity of Kamtschatka, and across to the Aleutian Islands by Kodiak, Sitka, and the islands of the west coast of North America to San Francisco. In the tropics these fish are found on the east coast of the Phillippines, and at the mouth of the Ganges in one genus and species, *Bregmaceros Macclellandi.* Only one genus and species is found in the Atlantic of the southern hemisphere, namely, the *Phycis brasiliensis* at Montevideo, likewise but one genus and species in the Pacific on the coast of Chili, *Merlucius Gayi*, and 2 genera with 3 species at New Zealand, *Lotella* and *Pseudophycis.* This is not surprising, since the coasts of Chili and New Zealand are under the influence of the cold antarctic currents, and Montevideo of the cold Cape Horn current, so that the antarctic drift ice even reaches at times up to that latitude. The fresh, cool water of the Hoang Ho, Yangtsekiang, Brahmapootra, and La Plata is favorable to the existence of *Gadidæ.*

Statistics show that the fisheries of the cod, which seem to be the most developed of the family *Gadidæ*, are most productive at Newfoundland and the Loffoden Islands, points 870 geographical miles apart. About midway lie Iceland and the Faroe Islands, which seem to form an inclosed region bounded on the north by Spitzbergen, Bear Islands, and Loffoden Islands. The center of this wide, oval, oceanic trough is most probably the northern home of the *Gadidæ.* Between Cape Charles, Cape Farewell, Southwestern Iceland, and the Gulf

Stream there is an Atlantic region of great depth, which is under the influence of the cold arctic current from the Davis' Strait and the Greenland Sea. This cold current deflects the Gulf Stream toward the European coast, and a second southern region of the *Gadidæ* is the result, which extends to the southeast of the above region, from Nova Scotia by the Azores to the Canaries and the Mediterranean and Black Seas. Both of the extreme points, Newfoundland and Loffoden (distant 25° of latitude one from the other), are poor in genera and species but very rich in individuals.* In the middle region, extending from southern Spitzbergen, Iceland, and the Faroe Islands past the British Islands and along the coast of France and Portugal to the Canaries, and especially Madeira, the number of species and genera increases from the north toward the south; but the number and size of the individuals diminish as the depth in which they live increases, a clear indication that the existence of these fish is dependent upon a particular temperature, for there are none to be found in localities under the influence of the prevailing arctic current or of the warm Gulf Stream. The northern region borders upon Spitzbergen, New Siberia, Parry Islands, and Greenland in the north, and upon Iceland, the Faroes, Southern Scandinavia, Russia, Siberia, the regions about Hudson's Bay, Canada, and Newfoundland on the south, comprising thus the whole Arctic Ocean and extending in a west-east direction 1,800 miles. It contains the following genera and species: *Gadus morrhua-callarias, æglefinus, virens, merlangus, luscus, nanus, saida, navaga, minutus, Fabricii; Merlucius communis, argentatus; Molva vulgaris; Motella tricirrata; Brosmius vulgaris, flavescens, Couchia argentata; Lota vulgaris;* that is, 7 genera with 18 species, in the average 3 species for every genus.

The Southern region is bounded by Nova Scotia, the Eastern coast of North America to Cape Hatteras, the Bermudas, the Azores, Canaries, the Mediterranean and the Black Seas, the coast of Portugal and France, the North and Baltic Seas, Southern Scandinavia, the Faroes and Southern Iceland back to the northern coast of Nova Scotia; thus it comprises the North Atlantic Ocean. The extent from the east coast of North America to the Black Sea is 1,245 miles. It contains the following genera and species: *Gadus morrhua-callarias, æglefinus, virens, Esmarkii, merlangus, luscus, nanus, minutus, pollachius, poutassou, euxinus, tomcodus; Gadiculus blennioides, argenteus; Hypsiptera argentea; Merlucius communis, argentatus; Molva vulgaris, abyssorum, elongata; Motella tricirrata, quinquecirrata, maculata, cimbria; Brosmius vulgaris; Raniceps trifurcatus; Couchia Edwardii, glauca, argentata; Lota vulgaris; Mora mediterranea; Chiasmodus niger; Halargyreus Johnsonii; Strinsia tinca; Physiculus Dalwigkii; Uraleptus Maraldi; Læmonema Yarellii, robustum; Haloporphyrus lepidion; Phycis blennioides, mediterranea, regalis, ameri-*

* Newfoundland has many genera and species of gadoids.

canus, brasiliensis; that is, 19 genera, with 44 species, in the average two species for every genus.*

In the Pacific Ocean the *Gadidæ* are distributed: on the west coast of North America to San Francisco, and of South America to Chili, and on the east coast of Asia from Behring Strait to Northern China, Chusan and by way of the Philippines to the mouth of the Ganges, and farther southward to New Zealand, not, however, as a connected series. The following are the genera and species: *Gadus morrhua, minutus, californicus, productus, macrocephalus, chalcogrammus; Merlucius Gayi; Motella pacifica; Lotella phycis, rhacinus, bacchus; Pseudophycis breviusculus; Bregmaceros Maclellandii;* that, is 6 genera with 13 species. The number of genera and species in the same ratio as in the Atlantic Ocean.

We shall now discuss more in detail the natural relations and the distribution of the genera and species in those three oceanic basins.

C.—THE ARCTIC REGION OF THE GADIDÆ.

Between the two large continental masses of the Old and the New World and almost entirely surrounded by them a great body of water is situated, which forms an immense inland sea of 1,826,000 square miles. This enormous sea is the basin of the Arctic and Atlantic Oceans. That these two oceans naturally form but one, is shown by the three connecting straits, whose breadth averages from, respectively 40 to 120 miles, while the Pacific Ocean has but one connection with the Arctic, the narrow Behring Strait. This great sea is naturally subdivided into three smaller basins, the Arctic, the North and the South Atlantic Oceans. The North Atlantic Ocean is connected with the Arctic and with the South Atlantic Ocean. The North Atlantic is, therefore, more particularly subject to the influence of the Arctic Ocean, while the latter, too, is influenced by the former, and this in return by the South Atlantic. The line of division of these three basins cannot be defined, as their natural characteristics are frequently blending with each other. The Arctic and North Atlantic Oceans are extraordinarily rich in large and small islands, between which straits and channels run, and they have numberless creeks, fiords, bays, and many inland seas of different size. Many and large rivers carry quantities of fresh water, sand, and detritus into these seas, and so form lagoons.

In consequence of this exceedingly rich development of the coast region the formation of fresh-water ice is favored, which, however, melts rapidly on account of the warm current from the South Atlantic Ocean, thus supplying, in conjunction with the rivers, the sea largely with wide and deep strata of fresh water.

The temperature, saltness, amount of food, currents, and depth of the sea are essential conditions for the distribution. The Arctic Ocean has, even in midsummer, according to Martius, a somewhat higher temperature at its surface than the air, in consequence of the Gulf Stream,

* Add *Phycis tinuis,* (Mitch.) DeKay. Two new species, *Haloporphyrus viola* and *Phycis Chesteri,* have recently been discovered in the southern region by the United States Fish Commission.

which not only reaches as far as the southern extremity of Spitzbergen, but up to Novaja Semlja, with a temperature as high as + 12.5 C. = 54.5° F., as has been ascertained by the imperial Russian expedition under Middendorf, in the summer of 1870.

It may be that this current runs along the northern coast of Siberia, cooling more and more by the influence of the ice and the cold water of the large Siberian rivers, and returns as cold arctic under current out of Behring Strait, as cold arctic surface-current through Davis Strait and the Greenland Sea. The channel between Iceland and Norway, 120 miles wide, serves the warm Atlantic current as entrance into the Arctic Ocean. Near Spitzbergen, even in 80° north latitude, the temperature of the water in the open sea was found by Gaimard to be never below + 0.7° C. = 33.26 F. near the surface, but nearly always + 1° C. = 33.8 F. According to the records of the Swedish expedition the water had in winter a temperature of −2° C. = 28.4° F. The temperature of the sea-water was found to be everywhere above 32° as far as 77° north latitude and as far west as the meridian of Greenwich, and none of the reports speak of ice. To the east of meridian 0 the temperature of the water at the surface is + 1, 2, 3, and over 4° C. = 33.3, 35.6, 37.4, 39.2° F.; in 75° 45′ north latitude, 4° east longitude from Greenwich, the surface of the sea showed 4.7° C. = 40.46° F. This is distant 230 sea miles W. N. W. from Bear's Island, where the monthly mean temperature in November, 1865, was observed − 5.4° C. = 22.28° F. and − 8.50° C. = 16.7° F. in December. The mean temperature of the water between Norway and Spitzbergen, 74° and 77 north latitude, was found to be + 3.94° C. = 39.1° F., and in 75° to 76° north latitude even + 5. C. = 41° F. perceptibly higher than that of the air, giving a mean of − 2.92° C. = 26.7° F.

In the inclosed parks of the sea and in the bays the enormous accumulation of ice, which the summer can never entirely melt, naturally exercises a chilling influence. Yet numerous fishes—cod, salmon, and herrings—inhabit the waters on the western coast of Spitzbergen 77° north latitude at Belsunde, surrounded by glaciers, and feeding upon the vast quantities of crustaceans.

While the temperature in the fiords and between the islands near the Norwegian coast is comparatively low, 3 to 4° C. = 37.4° to 39.2° F., at a distance from the coast it increases to a certain limit which for 69° and 70° latitude is 7° C. = 44.6° F., being about 15 geographical miles from the coast; the limits of the 6° C. = 42.8° F. and 5° C. = 41° F. are at a distance of 10 and 5 to 8 geographical miles respectively. Almost parallel with the 12° and 14° east longitude from Greenwich, the maximum temperature amounts to 4° and 5° C. = 39.4° and 41° F.; but while the isothermal of 5° keeps in the vicinity of the 72° latitude, the vertex of the isothermal of 4° lies in the latitude of the south cape of Spitzbergen, that is, 4° or 60 (German) geographical miles further north; in other words, a warm current runs along the 14th degree of longitude toward the north, while a similar arm branches off to the eastward along the coast of Finmark. In its further course the warm Atlantic current

divides into two arms at the west coast of Norway, one of which turns to the Murmanian coast, the other, west of Bear's Island, to the west coast of Spitzbergen. Concerning this second arm in winter-time, the Albert expedition has collected new information based upon positive observations. These show that the temperature diminishes to the eastward toward Bear's Island and East Spitzbergen. To the westward we find as limits of the warm water the isothermal of 0° (32° F.), which runs in a nearly north-south direction along the 10° and 11° longitude from the 73° to the 76° latitude; farther south it seems to turn to the west toward Jan Mayen. To the east of this curve for 0° (32° F.) the isothermal of 1°, 2°, and 3° (33.8°, 35.6°, 37.4° F.) are in pretty close proximity, indicating that the warm water has cooled off in a higher degree toward the limits of the icy water of the polar current. The observations of deep-sea temperatures made by the French expedition to Spitzbergen have shown that the warm water, without ever cooling below 0° (32° F.), occupies the whole depth of the sea between Norway, Bear's Island, and Spitzbergen; and, according to the assertion of Captain Otto, the experienced Norwegian seamen are well acquainted with the above-named current in spring and summer. From Captain Otto's observations it is positively ascertained that a warm current also at the beginning of winter is running west of Bear's Island to the western coast of Spitzbergen.

Ross, on the contrary, found that in Baffin's Bay, between 63° 49′ and 75° 44′ north latitude, the temperature of the water was above freezing only during thirty-one days in the months of June, July, August, and September; the rest of the time it was always below. The maximum was + 1.11° C. = 34° F.; the minimum − 1.11° C. = 30° F. In deep water, however, the temperature during July and August was constantly above 0, even at the greatest depth sounded, that of 3045 feet. As the temperature of the Arctic Ocean remains constant in great depths all the year round, it is easy to see how it can be the abode of many marine forms occurring there in deep water which in the North Atlantic Ocean are found near the surface or in its shallower parts. No fishes have been found up to the present time on the west coast of Greenland, near Hall's Land, in 81° 38′ north latitude, although nets and hooks have been used for the purpose; but the sea abounds in marine invertebrates, such as mollusca and crustacea, so that food for fishes is not wanting. The water at the Arctic region probably contains not more than 3 to 4 per cent. of salt; the general amount is about 3.3 per cent. The average depth of the Arctic Sea is very likely not more than 2,000 feet, and though near Spitzbergen a depth of 6,000 to 7,000 feet has been found, yet the water is very shallow along the Asiatic coast, the greatest depth north of the Behring Strait being only 220 fathoms = 1,320 feet. In 77° 2′ north latitude and 107° 40′ east longitude from Greenwich the depth is 245 feet English. The shallowest part in the Charles Foreland Sound, 79° 53′ north latitude, 16° 15′ 5″ east longitude from Greenwich, has a

depth of 12 feet, with sandy bottom. Spawn, young fry, and partly-developed fishes were found in water of a temperature of — 2° C.; unfortunately without stating genus and species. The depth of the water between Iceland and Greenland is 7,560 feet; that of the Juliushaab fiord, in Eastern Greenland, at least 900 feet.

In the Arctic Ocean the abundance of animal life contrasts strongly with the desolation of the land, the productions of the former often being of collossal dimensions; we only mention as an instance, the *Umbellularia* of 1.5 feet in size, which has lately been found. There are especially some families of fishes, small crustaceans, *ascidians*, *pteropods*, which are found in inexhaustible quantities, and serve as food of gigantic water-mammals and fishes.

The fishes of the Arctic Ocean are represented by extremely prolific families, as the *Salmonidæ* and *Gadidæ*. The *Gadidæ*, in particular, are found there in 6 different genera, with 13 or 14 species, namely, *Gadus*, with 8 or 9 species; *Molva vulgaris; Motella tricirrata*, *Brosmius vulgaris; Couchia argentata*, and *Lota vulgaris*. Their maximum, of course, is only found at the limits of the Arctic and in the North Atlantic Oceans. Two of the six above-named genera, including three species, are found near the southern coast of Spitzbergen, *Gadus morrhua*, *virens*, and *Molva vulgaris*. On the coast of Siberia, to the eastward of the mouth of the Indigirka, they disappear entirely, for only one genus is found there, according to Pallas, including one species, *Lota vulgaris*, this being the fresh-water type. It occurs at the mouth of a river, which falls into the Arctic Ocean, and at its extreme limits, and also at considerable elevations. Near the mouth of the Obi River 1 genus with 2 species is found, *Gadus luscus* and *navaga*. In the White Sea we find 1 genus with 3 species, *Gadus luscus*, *navaga*, and *saida*. The amount of salt in the water here is 3.2 per cent. Toward the west the number of genera and species increases rapidly with the higher temperature of the water. From Finmark to the Loffoden Islands the number of genera increases to 4, with 9 to 10 species: *Gadus*, with 6 or 7 species; *morrhua-callarias*, *æglefinus*, *virens*, *nanus*, *saida*, *navaga; Molva vulgaris; Brosmius vulgaris*, and *Lota vulgaris*, which lives in Lake Belemis, in Russian Lapland, and other lakes and rivers. From this the conclusion may be drawn that the limits of the *Gadidæ* for the eastern portion of the Arctic Ocean are the mouth of the Indigirka in the east, Spitzbergen and New Siberia in the north.

Iceland and the Faroe Islands are situated where the Arctic and North Atlantic Oceans join. Iceland has a perfectly isolated situation, for its distance from Norway is 120, from the Faroe Islands, 50, and from East Greenland, 40 miles. According to Fred. Faber, 1829, the *Gadidæ* are represented around Iceland by 1 genus with 11 species; but according to recent determination, 4 genera with 11 species, viz: *Gadus*, with 6 or 7 species, *morrhua-callarias*, *æglefinus*, *virens*, *merlangus*, *nanus*, *Fabricii; Merlucius*, with two species, *communis*, *argentatus; Molva*

vulgaris, and *Brosmius vulgaris*. Iceland and Finmark have nearly the same genera of *Gadidæ* in common, viz: *Gadus*, *Molva*, and *Brosmius*. The genus *Merlucius*, with two species, and *Gadus Fabricii* are found in Iceland, but not in Finmark. The Faroe Islands have also four genera, but only 7 or 8 species: *Gadus*, with 4 or 5 species; *morrhua-callarias*, *æglefinus*, *virens*, *merlangus*; *Merlucius communis*; *Molva vulgaris*, and *Brosmius vulgaris*. Although these islands are situated about 2° farther south than Iceland, yet they produce less of the *Gadidæ*. This is probably caused by the violent cold current, the great depth, and extreme saltness of the water around these islands. The genera and species of *Gadidæ*, common to Iceland and the Faroe Islands, are *Gadus morrhua-callarias*, *æglefinus*, *virens*; *Molva vulgaris*, *Brosmius vulgaris*, and *Merlucius communis*; thus the purely northern types, *Gadus nanus*, *Fabricii*, and *Merlucius argentatus*, do not occur. The diminution of species and individuals, as also the disappearance of the northern types, indicate that Iceland and the Faroe Islands are situated at the southern limits of the northern region of the *Gadidæ*.

A powerful, cold Arctic current, proceeding from the Greenland Sea, between Greenland and Iceland to the south, joins a similar one from Davis and Hudson Straits. This current in its course southward crosses about 10° of latitude, a distance of 150 (German) geographical miles. It is deflected to the east by the rotation of the earth and the direction of the meeting currents, and combines, in 48° north latitude, and 40° east longitude, Greenwich, with the very warm Gulf Stream (16° C. = 60.8 F.) coming from the South Atlantic Ocean, and also deflected east. They cross each other; the lighter and warmer Gulf Stream continues its course near the surface, while the Arctic current, passing underneath the Gulf Stream, appears as surface-current near the Azores, onward to the Mediterranean, Madeira, and the Canary Islands. The Arctic current removes the *Gadidæ* region on the American coast 25 degrees or 375 geographical miles farther south than on the European, and the limit of the inhabitable region for them on the African coast 5° farther south than on the American.

The southern limits of the Arctic *Gadidæ* region run from the south of Iceland east and south around the Bank of Newfoundland to the Bay of St. Lawrence. No *Gadidæ* are found in the entire region of the cold Arctic current in the North Atlantic Ocean; its depth is too great by far, amounting to 17,700 feet between Iceland and Newfoundland. This cold current divides the Arctic *Gadidæ* region into an eastern and western part. The latter includes Greenland, Newfoundland and its bank, the Bay of St. Lawrence, Labrador, the countries bordering on the Hudson Bay, as also Arctic North America with its islands as far as Behring Strait.

In Greenland occur, according to Reinhardt, 4 genera and 10 or 11 species of *Gadidæ*, some of them rare, and the classification of others uncertain; but it has undoubtedly few species, only as many as Ice-

land, although it extends farther north and south. According to a more recent determination, 4 genera with only 9 or 10 species, and two rare genera and species are found: *Gadus*, with 6 or 7 species, *morrhua-callarias, æglefinus, virens, luscus, merlangus, nanus; Molva vulgaris; Motella tricirrata; Couchia argentata; Brosmius vulgaris* rarely occurs, and *Merlucius communis* still more so, which leads to the conclusion that the temperature of the water is very low.

Newfoundland.—The banks around Newfoundland are not, as is often supposed, sand masses accumulated there by the St. Lawrence River and the Gulf Stream, but a rocky submarine plateau, whose eastern and southern borders steeply descend to a great depth. Farthest to the eastward lies the Outer or false Bank 47° north 45° west, upon which the sea has a depth of 600 feet to 900 feet; the Great Bank extends over fully nine degrees of latitude from north to south; from west to east it covers in some places five degrees. The depth of the water varies from 50 to 360 feet; from the coast to the western border it is from 120 to 360 feet. The bottom around the southern part of the island consists of an uninterrupted series of shallows as far as Cape Breton and Sable Island. To the west there are several smaller banks, for instance, Porgoise Bank, Banquereau and Mizen Bank. The current of the sea strikes with great impetuosity against the borders of the bank and is thrown back from them with equal violence, while upon the bank itself the water is as smooth as in a harbor, if not agitated by heavy storms from a distance.

Remarkable results were obtained by the soundings and thermometrical observations of Commander Chimno of the English ship Gannet. He found a depth of 9,000 feet at the west end of the Great Bank. The sediment had a temperature of 13.3° C., about 55.9° F., but the sea-water was only 4.6° C. = 40.3° F. at a depth of 6,000 feet, and even only 4.1° C. = 39.4° F. at 3,000 feet; the surface temperature was 15.5° C. = 59.9° F. In 43° 20′ north latitude and 60° west longitude from Greenwich, thirty miles to the south of the Sand Island, the depth was 15,600 feet. In 44° 3′ north latitude and 48° 7′ west longitude from Greenwich the sea was 9,900 feet deep.

Temperature at the sea's surface, 16.1° C. = 60.9° F.
at a depth of 300 feet, 6° = 42.8° F.
at a depth of 6,000 feet, 4.1° = 39.2° F.

The depth around the bank is from 10,000 to 15,000 feet. Upon the bank the water is not warmer than the surrounding is at a depth of 300 feet to 6,000 feet, namely, 4 to 6° C. = 39.2 to 42.8° F.

The "fishing-grounds," "cod-meadows," have an extent of about 200 geographical miles in length and 67 miles in breadth, and the yield of the cod fishery has not decreased since nearly 400 years. The codfish represents, then, the principal item of the national wealth around Newfoundland, upon the Bank, on the Bay of St. Lawrence, and the coast of Labrador, and the capture of this fish furnishes not only employment for entire fleets of the North Americans, but English, French, and Dutch-

men participate largely in it. In the Arctic *Gadidæ* region we find the greatest abundance of individuals, particularly in the eastern part near the Loffoden Islands and Finmark, and in the western part in the vicinity of Newfoundland and Labrador. The Bank of Newfoundland and the Bay of St. Lawrence form an extensive sea of fresh water, which receives continually new supplies from the Canadian lakes through the mighty St. Lawrence River.

Upon the Bank only three genera, with six or seven species of the *Gadidæ*, are found; not many more genera occur near the Loffoden Islands and Finmark, and few more species. Upon closer examination a few more species may be found there yet, but certainly not more than two or three; for the abundance of individuals reduces the number of genera and species; and a variety of food is wanting, too. The following genera and species are represented here: *Gadus*, with four or five species, *morrhua-callarias*, *æglefinus*, *virens*, *minutus; Molva vulgaris; Brosmius flavescens*, the latter being peculiar to the Bank.

Toward the northwest, the arctic *Gadidæ* region may be continued along the northern coast of North America. It extends from the coasts of Labrador to the 74° latitude, and to Behring Strait. The Hudson Bay and the Polar Sea, north of North America, are only slightly salt, on account of the influx from the American lakes and rivers; but the temperature of the water is low, and consequently the arctic *Gadidæ* are not numerous.

From Labrador to the peninsula of Boothia and 74° latitude, only two genera are found, including five or six species, *Gadus morrhua-callarias*, *virens*, *Fabricii*, and *merlangus*, which are captured in Baffin's Bay, in 74° latitude.

In the numerous rivers and lakes *Lota vulgaris* is found, the roe of which is used by fur-dealers for baking bread and tea-cakes. To the west of Boothia, as far as the mouth of the Mackenzie River, Beechey Island, and Behring Strait, the genus *Gadus* is represented by only two to three species, *morrhua callarius*, *Fabricii*. The range of the latter extends to Beechey Island. Capt. James Ross says: "We found four species of this fish on the northern coast of America and along the western coast of the peninsula of Boothia. They are common also in Davis Strait and Baffin's Bay, and two of them inhabit the sea east of Boothia likewise. The arctic *Gadidæ* are migrating fishes. In the eastern part they probably inhabit a submarine plateau, situated between Iceland, Jan Mayen, Spitzbergen, Bear's Island, Norway, and the Faroe Islands. From there they visit Spitzbergen, Iceland, Norway, traveling from 60 to 70 or 80 miles; certainly a considerable distance. In the western part, the abode of the *Gadidæ* must not be sought for to the north of Greenland and Iceland. It is either upon the Banks of Newfoundland themselves, or farther east, on the Northern Fucus Bank; for this yields an inexhaustible quantity of food, and the bank, with its calm, fresh water, offers desirable spawning-grounds. To reach these

the *Gadidæ* need not traverse the icy Arctic current; they have but to seek for the cool and fresh water of the bank. Adding to this that the distance from Greenland and Iceland is about 200 or 300 geographical miles, while from the Northern Fucus Bank to the Bank of Newfoundland it is but 100 miles, it is therefore more natural that the fishes migrate from the Fucus Bank than from Greenland and Iceland. If the Fucus Bank were scientifically examined, we should obtain certainty in regard to this question.

The two parts of the Arctic *Gadidæ* region are separated, from the mouth of the Indigirka to Behring Strait on the one side, and from the mouth of the Mackenzie and Beechey Island on the other. Probably these two parts diffuse through the depth and unite at the Behring Strait, and through it spread into the Pacific Ocean, along the American and Asiatic coast; for some *Gadidæ* of the Arctic type are met with in the northern parts of the Pacific. The abundance of individuals is very great on the two opposite coasts.

D.—THE ATLANTIC REGION OF THE GADIDÆ.

The Atlantic region of the *Gadidæ* comprises the sea extending along the eastern shores of North America from Nova Scotia to the 35th parallel; Cape Hatteras; from there in an easterly direction to the Azores by way of the Fucus Bank, extending as far north as Great Britain; the German Ocean and the Baltic, and south through the Mediterranean Sea as far as the Black Sea, and by way of Madeira to the South Canary Islands. We are unfortunately not acquainted with the fish-fauna of the Bermuda Islands and the Azores, but it is probable that here, too, some Atlantic forms of this widely-spread family will be found, as they occur very frequently near Madeira.

The Fucus Bank divides the region into two uneven parts, the Atlantic region of the *Gadidæ*, extending east and west of this bank. The western part, along the coast of North America, is the smaller of the two. South of Nova Scotia, as far as Philadelphia and Cape Hatteras, we find only 4 genera with 9–10 species, northern and southern fish living together within a small space.

East of the Fucus Bank the *Gadidæ* fauna changes very suddenly, exhibiting greater variety of form, size, and mode of life. In the north, we begin with the Scandinavian *Gadidæ*. Near the Scandinavian and the Cimbric peninsulas, the Danish Islands, and in the seas surrounded by these countries, there is a very rich *Gadidæ* fauna, rich not so much in individuals as in genera and species. According to Nilsson's account, of 1855, we find here 4 genera, with 17 species, but, according to more recent accounts, 8 genera, with 18–19 species. Southern Scandinavia and Denmark have, besides many northern varieties, genera and species of the *Gadidæ*, which never occur as far north as Finmarken, Iceland, and the Faroe Islands.

The geographical location, near a large mass of land, the size and physical character of the British Islands, is favorable to a large number of different fish, which find many excellent spawning and feeding places and plenty of food of every kind in the tepid sea, the shallow bottom, and the many bays and estuaries. Such a location is particularly favorable for the *Gadidæ*, which show a tendency to change genus and species at the expense of the number of individuals. We therefore find near the British Islands a great variety of genera, and the greatest variety of species of *Gadidæ* occurring anywhere in the world, viz, 40 per cent.

Although I am not prepared to give statistics of the cod fisheries near the British Islands, as the codfish are here mostly eaten fresh and do not get into the market in a preserved state, I know for certain that the different species never occur in such large schools as near the Loffoden Islands, near Finmarken, and near the Banks of Newfoundland. According to Yarrel, there are near the British Islands 9 genera and 22 species of *Gadidæ*; but, according to Dr. Günther's account, of 1868, there are 10 genera and 23–24 species, out of 60 species, found in the whole world. Among these there are many southern varieties of the *Gadidæ*, showing in a very marked manner the influence of the Gulf Stream; such as *Gadus poutassou*, *Motella maculata*, *Phycis blennioides*; and still the British Islands are only four degrees farther south than Denmark.

Toward the western coasts of France and Cantabria the *Gadidæ* almost disappear; only two northern varieties, *Gadus callarias* and *Gadus luscus*, occurring in these waters. This astonishing change can only be explained by the fact that the Aquitanian Sea, which is very deep, has very cold, briny water, which the *Gadidæ* do not like. It is possible that a submarine Arctic stream flows into this submarine cave, driving out all animal life. Such a stream must turn north of the Fucus Bank; for south of Cape Finisterre we find a great change in animal life, and the farther south we get the greater is the variety of species. Already between the Azores and the Portugese coast we meet with entirely new varieties; still more is this the case near Madeira and in the western part of the Mediterranean, while these varieties disappear near the South Canary Islands, in the eastern part of the Mediterranean, and in the Black Sea.

On the coast of Portugal northern and southern varieties are mixed in a very peculiar manner. The genus *Gadus* has left its genuine representatives behind, and from the southern region no distinct varieties are found; consequently, we find there only transition varieties from both regions. There are, nevertheless, in these waters, 3 genera with 6 species, viz: *Gadus* with 4 species, *luscus*, *pollachius*, *poutassou*, *Merlucius communis*; *Motella*, with 2 species, *quinquecirrata*, *maculata*. *Gadus luscus* and *Motella quinquecirrata* are northern, and *Gadus poutassou* and *Motella maculata* southern varieties.

Near the North Canary Islands, especially near Madeira, the south-

ern varieties of the *Gadidæ* very suddenly occur in great numbers, not so much as regards individuals and species, but as regards genera, and these partly live at a great depth, which the *Gadidæ* do not do otherwise. This shows that the water is not very briny, that its temperature is moderate, and that there is great abundance and variety of food. According to Lowe's account (1846), only *Macrurus atlanticus* occurs near Madeira; this fish does not even belong to the *Gadidæ*, while Dr. Günther, in 1868, found in the same waters no less than 10 genera and 12 species of *Gadidæ*.

The Mediterranean contains a considerable number of *Gadidæ* even in proportion to its fish fauna, which is peculiarly rich in genera and species. As regards the genera, they are about evenly divided between northern and southern varieties, while in the species there is a very striking preponderance of northern varieties. This is only another proof of the law of nature, that the torrid zone is rich in genera, the temperate zone in species, and the frigid zone in individuals. According to Risso, we find in the Mediterranean 6 genera with 11 species, and according to Dr. Günther (1868), 10 genera with 19 species. There is a remarkable difference between the western and eastern parts of the Mediterranean. The western part extends from the Strait of Gibraltar as far as the Strait of Messina; in the eastern part we include the Black Sea. *Strinsia tinca* is a variety of the *Gadidæ* peculiar to the Mediterranean. By the predominance of the genus *Gadus* the Mediterranean has a northern character, which, however, is strongly varied by a strong addition of South Madeira varieties. As there are near the North Canary Islands, and in the western part of the Mediterranean, 10 genera of *Gadidæ* out of a total number of 22— more than 45 per cent.—we find here the greatest number of genera.

In the Black Sea there are only 2 genera with 2 species, viz, *Gadus euxinus* and *Lota vulgaris*. Four genera with five species, among these two deep-water fish, are peculiar to the North Canary Islands and Madeira. Near the South Canary Islands, which are 40–50 geographical miles farther south, we find only *Mora mediterranea*. The Atlantic region is thus indicated by a distinct border-line. The temperature of the water is +6 to +8 degrees, Celsius.

As a scattered northern variety we find, strange to say, *Lota vulgaris* near Pine Island on the southwest point of Florida.* The occurrence of this genus in the lagoons of West Key can only be explained by supposing that *Lota vulgaris* belonged to the Mississippi, went into the sea to escape the great heat in the river, and was then driven by the hot Gulf Stream into the fresh-water stream near the coast. As a scattered southern variety, we find in the south temperate zone of the Atlantic Ocean, via the mouth of the La Plata River, near Montevideo, *Phycis brasiliensis*, which is, of course, peculiar to those waters.

* *Lota maculosa*, which is the species referred to, has not been recorded from farther south than Kansas City, Missouri. Pine Island Lake, in the Hudson's Bay region, is, perhaps, the locality intended.—B.

We thus find in the Arctic Atlantic Ocean four central regions of the *Gadidæ*, two in the north and two in the south. The first central region is about fifty to sixty geographical miles broad, about eight to ten geographical miles distant from the coast of Norway, running parallel with it between Bear Island and the Faroe Islands; therefore, within the limits of the above-mentioned warm stream. The second central region extending about two hundred and twelve geographical miles in length and 150 in breadth, is near Newfoundland and the Northern Fucus Bank. In both these regions the number of individuals is very large. In the South the first central region with 40 per cent. of species is near the British Islands, and the second with 45 per cent. of genera extends from the North Canary Islands as far as the western part of the Mediterranean. In the south the *Gadidæ* are stationary fish, which, near Great Britain, in the German Ocean, the Baltic, the Doggers Bank, the Fish Bank, Nymph Bank, Hollergrund, &c., are with more or less success caught all the year round.

E.—THE PACIFIC REGION OF THE GADIDÆ.

The North Pacific Ocean is not much influenced by the Arctic Ocean, as is shown by its fish-fauna. In the Behring Sea, the surrounding islands are on the American and Asiatic coasts. Arctic transition varieties and Pacific varieties are found together. Only one genus is found there with three, and according to Pallas five, species. On the eastern coast of Asia, in the Sea of Ochotsk, near Kamtschatka, the Kurile Islands and the island of Saghalien the same genus with the same species is found; but in the latitude of Newfoundland, near Saghalien, perhaps with the same wealth of individuals, so that the Japanese had numerous fisheries in the southern part of Saghalien which recently have passed into the hands of the Russians. We, therefore, likewise find here in the North few genera and species, but numerous individuals. On the west coast of Japan we find instead of these *Gadidæ* two new genera and species.

Farther south, on the north and east coast of China, west of the Philippine Islands, at the mouth of the Ganges and the Brahmapootra, we again find a peculiar genus and species of the *Gadidæ*. This is the only tropical variety, and its being found near the mouth of the Ganges and Brahmapootra can only be explained by the fact that the Brahmapootra brings a considerable quantity of cold, fresh water from the Himalaya Mountains, and that there is abundant food. Similar causes must exist near the Chinese coast and the Philippine Islands. A cold current certainly comes from the Sea of Ochotsk, goes through the Sea of Japan and the North China Sea and extends as far as Formosa and the west coast of the Philippine Islands. If we go in the direction of the Philippine Islands, passing the Central Australasian Islands, we do not meet with any *Gadidæ* till we have passed the equator and have reached the

south temperate zone near New Zealand. Here we find two genera with three species, viz, the genus *Lotella*, which we first found near Japan, but here with two new species, viz, *rhacinus* and *bacchus*, and a new genus and species *Pseudophycis breviusculus*. There is no other place on the whole southern hemisphere where the *Gadidæ* are so numerous, both as regards genera and species as here. The fact of so many *Gadidæ* being found on the west coast of New Zealand is explained by the peculiar condition of the sea, regarding which the voyage of the Gazelle has furnished us with more detailed information. According to the observations made by Baron von Schleinitz, on board the Gazelle, the temperature of the water on the northwest coast of New Zealand is the following: At a depth of 200 fathoms or 366 meters, 10 degrees C.; at a depth of 400 fathoms or 732 metres, 6 to 8 degrees C.; and at a depth of 600 fathoms or 1097 meters, only 4 degrees C. The quantity of brine is only 0.58 to 0.59 per cent.

On the west coast of North America, between Kodjak and Sitka, near Vancouver Island, and as far south as California, there is only one genus with five species. In the north, between Kodjak and Sitka, as far as Vancouver Island, the genus *Gadus* is represented by the species *morrhua*, *minutus*, and *macrocephalus*. *Gadus minutus* is found especially near Mount St. Elias. In the bay between Kodjak and Sitka there are large codfisheries. We therefore likewise find here northern varieties mixed with Pacific varieties; but the northern varieties preponderate by the number of individuals and species. Farther south, on the coast of California as far as San Francisco, we find two other species of *Gadidæ*. Even as far south as this, the cold Arctic currents may be traced, although of course they have lost a good deal of their original coldness. The *Gadidæ* now disappear for a long distance along the west coast of America, and we do not meet them till beyond the equator, in the south temperate zone, on the coast of Chili, which is under the influence of the cool Antarctic current. Here we find a northern genus, but with a peculiar species, viz, *Merlucius Gayi*.

In the Pacific Ocean we therefore find the largest number of individuals between Kodjak and Sitka and near Saghalien, the largest number of species on the coast of Asia, and the largest number of genera near Japan and New Zealand.

F.—DISTRIBUTION AND FISHING OF THE DIFFERENT SPECIES.

a. The following are specifically Arctic varieties of the *Gadidæ*: *Gadus saida* is found in the White Sea, having 3.2 per cent. brine. *Gadus navaga* is likewise found in the White Sea and on the coast of Northern Russia. *Merlucius argentatus*, *G.* is only found near Iceland. *Gadus Fabricii* is very common in the north frigid zone of the western hemisphere, from Iceland to Baffin's Bay and Beechey Island. Quantity of brine, 3.3 per cent.; temperature of water, 1–2 degrees C.

b. The following are the Arctic-Atlantic varieties of the *Gadidæ: Gadus morrhua L.* is found in all the seas of the northern hemisphere from 40–77 degrees northern latitude, and even enters the mouths of rivers, *e. g.*, the Tweed. In the Atlantic Ocean it is found from New York as far as Hudson's Bay, and from Finmarken and Iceland as far as the German Ocean. Between the 45th and 71st degrees northern latitude it is found in almost incredible quantities. Near Spitzbergen Marteus did not find it, but according to others it is found there. It is found in moderate numbers on the west and east coast of Greenland; but from Finmarken to the Loffoden Islands, and from Iceland to Nova Scotia, it is found in enormous quantities. It has been caught near the Faroe Islands, the Shetland and Orkney Islands, the Hebrides, near Great Britain, the Irish Sea, the German Ocean, *e. g.*, east-northeast from Bamborough, at a depth of 204 feet, the Skagerak, the Kattegat, and the Baltic. It seems to prefer entering the Baltic through the Sound rather than through the Great Belt. On the German coast it is found near Kiel and the Stollergrund, at a depth of 7 fathoms, with a water-temperature of 4–5 degrees C., and 1.44 per cent. brine; on the coast of Sweden, near Bohuslãn and Ronehamm, on the island of Gothland. Twenty-seven nautical miles from Ronehamm the percentage of brine at a depth of 65 fathoms is 0.82, and 41 nautical miles from Ronehamm, at a depth of 96 fathoms, it is 1.02. It is found as far as Dalarõ, near Stockholm, where, at a depth of 5½ fathoms, it is 0.59, and a depth of 40 fathoms, 0.75. East and north of North America it is found in every bay and in all shallow waters, in enormous numbers; near Newfoundland, Nova Scotia, and Labrador, as far as the Chaleur Bay in Canada, and as far south as Philadelphia. In the Pacific Ocean it is found in the Sea of Ochotsk, the Behring Sea, near the Fox and Shumaghin Islands, south of Alaska, and on the west coast of North America, in the bay between the island of Sitka and Kodjak; therefore between the 50th and 67½ degrees northern latitude.*

In three salt-water ponds in Scotland, in Gallaway, Fife, and Orkney, codfish are kept and flourish very well. Yarrell distinguishes two varieties: A darker one, south of Great Britain and near the Dogger's Bank; and a lighter one, north of Scotland and near the Scotch Islands.

Fishing.—Fifty years ago the codfisheries north and east of Iceland decreased very much. The Dutch fishers nevertheless caught a good many, proving that the fish were there in considerable numbers, but kept in deep water. Near the Faroe Islands an annual decrease in the number of fish was noticed, while it was caught in considerable quantities on the north coast of Funen and Zealand. At the present time it is frequently caught in nets on the Nymph Bank and Doggers Bank, near the Loffoden Islands and Finmarken, at a depth of 5–6 fathoms, and on the bank of Newfoundland it is caught with lines at a depth of 3–4 fathoms, and also in large quantities in the Pacific Ocean between Sitka and Kodjak.

---

* *Gadus morrhua* is not known to occur in the Pacific Ocean.

Gadus callarias L. is, according to Dr. Günther, the juvenile variety of the codfish. Both kinds are actually found together in most regions, but we must also state that there are regions where *Gadus morrhua* but no *Gadus callarias* is found, *e. g.*, near Spitzbergen and in the Pacific Ocean; and *Gadus callarias* occurs in places where *Gadus morrhua* has so far not been observed, *e. g.*, on the west coast of France. This certainly is no proof against *Gadus callarias* being the juvenile variety, and is not intended as such; it is only intended to prove that *Gadus callarias* is not found as far north as the codfish, but occurs more in the south, probably because, as a juvenile variety, it is more sensitive to temperature and very briny water. It is found just as frequently on the coast of Iceland as on the coast of Denmark, and occurs near the Faroe Islands, Great Britain, Norway, and Finmarken. It is common in the German Ocean, on the Doggers Bank, and near Heligoland. It is larger and more frequent in the Baltic, especially on the coasts of Germany, Courland, Esthonia, and Livonia, but is not found near St. Petersburg. On the coast of Courland, eighteen nautical miles southwest of Liban, the percentage of brine at a depth of 21 fathoms is only 0.77. The stream-cod, which lives in currents of the sea, is said not to be as good as that living in calm water. It is a remarkable fact that the common codfish lives and spawns in company with other fish in a fresh-water lake near the northern shore of Iceland, called Olafsvate, which is separated from the sea by a narrow sand-reef, and was probably in former times a bay of the sea, whose entrance has been closed up by sand, but which receives fresh water from some spring. Thus *Gadus morrhua*, in its juvenile variety, *callarias*, here shows the genuine characteristics of a fresh-water fish. It is also found near Greenland, and Capt. James Ross says: "On the north coast of America and along the coasts of the passage west of the Boothia Peninsula we found 4 species of these fish (*Gadidæ*), which are also common in Davis Strait and Baffin's Bay; two of these species inhabit the sea east of Boothia." This fish is therefore found all through the northern seas and on the coasts of the United States as far as New York.

Yarrell says that there are four varieties; these are occasioned by its different location. It keeps on clayey bottom or on rocky bottom where there are many sea-weeds, and has a more grayish or reddish color according to its location. *Gadus æglefinus L.* is found very frequently in the northern seas. It occurs quite often near the coasts of Greenland and the Faroe Islands, and is very common near the coasts of Norway, Scotland, and Iceland; not so frequent, however, on the northern coast of the last-mentioned island, and is everywhere exceeded in numbers by the *Gadus morrhua.* It is numerous on the American coasts of the North Atlantic Ocean, especially in the Gulf of St. Lawrence. According to Schonevelde it is found in the Schlei, near Eckernförde and near Kiel. Near Eckernförde the depth is 6 fathoms, and the percentage of brine 1.51.

Fishing.—The largest fish are caught in the Bay of Dublin and on the Nymph Bank. It is frequently caught in the German Ocean, near Heligoland, on the west coast of Schleswig near Sylt, and on the Doggers Bank, in the Skagerak, the Kattegat, and on the Danish coasts, especially near Elsinore.

Gadus virens, L., lives in the North Atlantic Ocean and in the Polar Sea as far south as the 46th degree northern latitude, and is found from the British coasts as far as Finmarken and Spitzbergen, and from the Baltic to the coasts of North America. In Iceland it keeps chiefly near the south and west side of the island and does not seem to leave this coast; on the Swedish coast it is found near Bohuslän; near the British coasts it is found in the Frith of Forth and near Palperro. From there on it does not occur till the Mediterranean is reached.

Fishing.—On the coasts of the Faroe Islands and Norway these fish during certain years appear in such quantities in summer and autumn that nearly all the bays are filled with them; this is also the case near the Isle of Man and in the Mediterranean. On the north coast of Jutland they also occasionally appear in large numbers; but in the south of Denmark they are but seldom caught, and then chiefly in spring and autumn. Near Greenland they are seldom caught, more frequently in Davis Strait, on the bank and near Boston.

Gadus luscus, L., chiefly lives in the Polar Sea and the northern seas but goes farther south than the above-mentioned varieties. Near Great Britain, as far north as the coast of Sweden and Norway, east on the coast of Siberia as far as the Obi River, it is a most highly esteemed fish. It is found south on the coasts of Germany, the Netherlands, France, and Portugal (near Lisbon), and as far as the western part of the Mediterranean, the Bay of Naples, and Sicily; also near Greenland; it is found at a depth of 96 feet, 1½ miles east southeast of Lowestoft.

Gadus merlangus, L., is found far north, but not in any great number. Its home is therefore south of the 60th degree northern latitude. It is not found near the east of Greenland and the north of Iceland, and it is rare near the south of Iceland and the Faroe Islands; it occurs frequently near the south coast of Norway, near Arendal, near Great Britain and the Orkney Islands. On the heights of Arendal the percentage of brine at a depth of 364 fathoms was 3.53. Near Iceland Faber found it all the year round only in the bay of Reikiavick. It is found at a depth of 204 feet east-northeast of Bamborough.

Fishing.—Near the Danish coasts, in the German Ocean and in the Baltic, it is common from May to September, especially on the Dogger's Bank, the Nymph Bank, and on the south coast of Iceland; it is also very frequent on the coasts of Southwestern Europe. It does not seem to occur on the western coast of the Cimbric peninsula, because it likes a sandy and moory bottom at a depth of about 360 feet, and therefore scarcely ever enters the shallow bays.

Gadus nanus Faber, the northern dwarf codfish, is found near the south

of Greenland, near Iceland only in the southwest, but very frequently in the Bay of Reickiavick; also from Finmarken, along the coast of Sweden and Norway, as far as Bohuslän, near Denmark and England.

Fishing.—In September this species, without being mixed with the *Gadus morrhua*, is caught near Iceland in vast numbers; it is distinguished by its small size and reddish color. Near Greenland and Denmark it is very common in winter.

Gadus minutus, L., the southern dwarf codfish, is very common in deep waters, and generally near the bottom at a depth of 1,000 feet. It is not found north of the 60th degree north latitude, but is found from the Baltic and German Ocean as far south as the Mediterranean, in the west on the eastern coast of North America, on the bank, near Boston and New York; but also on the western coast of North America, near Mount St. Elias. It is also called "Kagelin," and is used as bait in catching codfish. It is found at a depth of 96 feet, 1½ miles east-southeast of Lowestoft.*

Molva vulgaris, Flem., is found in the north between the 77th and 35th degrees northern latitude, from Spitzbergen to the Mediterranean, especially on the northern coasts of Europe as far as Iceland. The German Ocean, however, and the coasts of Norway seem to be his proper home, for here it is very common as far as Finmarken. On the coasts of Iceland it is found everywhere; it is rare in the north of Iceland, although it has been found as far as Grimsö; toward the west it gets more frequent, less so on the south coast. It is not very common, either, on the coasts of Greenland and the Faroe Islands, and it is not found in the Kattegat and the Baltic, while it occurs near the Bank of Newfoundland. It generally keeps near the bottom, and loves deep water more than common codfish; it is found on sandy and rocky bottom, at a depth of about 600 feet.

Fishing.—They are chiefly caught between Trondhjem and Bergen. The latter city alone furnishes about a million pounds every year. Next to the codfish and the herring it is the most common fish in the market. In Denmark it is caught by the fishermen on the west coast of Jutland as far as Heligoland. Large numbers are also caught near the western British Islands, the Orkney Islands, on the coast of Yorkshire, Cornwall, near the Scilly Islands, and nearly along the whole coast of Ireland. Near Iceland it is chiefly caught near Westjökul.

Brosmius vulgaris, Flem., or the small-headed cod, is chiefly found in the north, and on the European coasts it is not found much farther south than the 60th degree northern latitude, and not much farther north than the 70th degree. Large numbers are found on the coasts of Norway as far as Finmarken, on the west and south coasts of Iceland, and near the Faroe Islands, the Shetland and Orkney Islands, and the Frith of Forth; it is only found near the most northern point of Denmark, where it is occasionally caught near Skagen, in Jutland. It is not caught on the southern coasts of Denmark. It seldom occurs near the north and east

* The writer has confused several species under the name *Gadus minutus*.

coast of Iceland ; it is said to be rare near Greenland, while it is frequent near Boston, thus being found 15 degrees farther south on the western shores of the North Atlantic Ocean than on its eastern shores. This fact certainly is a striking proof of the influence of the Arctic current. It lives in deep waters where sea-weeds grow, and is consequently but little known and rarely caught even in localities where it is frequent.*

We will, among the last of the Arctic-Atlantic varieties, mention the one which is mostly found in fresh water, viz, the *Lota vulgaris*. This fish is found throughout the greater portion of Central, Northern, and Eastern Europe as far as the western, northern and northeastern portion of Asia and the northern portion of North America (*Lota maculosa*). Its most westerly limit in Europe is in the Rhine, near Manheim ; it is common in the Reuss, near Sissingen, and in the Lake of Constance, in the Weser, the Elbe, the Moldau, near Budweiss in Bohemia, near Teschen on the Oder, and in the Vistula. It is very common in the region of the Danube, in the Danube near Passau, in the Salzach, the Weitra, in the Traun Lake, the Atter Lake, Hallstädter Lake, Fuschler Lake, Mond Lake, and Zirknitzer Lake ; in the river Drau, in the river Ramp near Zwettel, near Datschiz in Moravia, in Transylvania, in the river Stry in Galicia. The most southerly point where it is found in the region of the Po is the Garda Lake. It is found in the Swiss lakes, in the St. Maurice Lake at a height of 5,580 feet, and in the Lake of Seelisberg, near the Lake of the Four Cantons at a height of 2,240 feet. On the other side of the channel it is found in the west of England and in Scotland, in Norfolk, Lincolnshire, Yorkshire, Durham, in the rivers Cam, Trent, Thames, Ouse, Esk, Skern, Tees, Derwent, and also in the Firth of Forth; also in Central Scandinavia—Götaelf—and Northern Scandinavia, in Finmarken and Lapland. In Russia it is found nearly everywhere, in the Neva near St. Petersburg, in Lake Balamis in Russian Lapland, according to Rathke, in the Black Sea, and, according to Pallas, in the Obi River ; it is very common in the river Lena and in the Northern Polar Sea as far as the Indigirka River, also in the Penshina River which flows into the Sea of Ochotsk. In North America it is common in Canada and in the neighboring portions of the United States, as well as in the lakes and rivers of the Hudson Bay region. It is found in Lake Madawaska in Canada, and in the sea near Pine Island in the Strait of Florida.† It likes the deep, cool, and clear bays of the sea or the deep basins of the ocean, but it is likewise found in large and small rivers and ponds both in flat and mountainous countries, in lakes frequently at a depth of 180 to 240 feet.

c. The following are Scandinavian varieties: *Gadus Esmarkii Nilss.* is only found on the south coast of Norway, in the Christiana fiord. *Molva abyssorum Nilss.* is perhaps the same as the *Gadus barbatus* in

* Sea-weeds do not grow in water deeper than 25 fathoms. *Brosmius vulgaris* (= *B. brosme*) is by no means rarely caught.—B.

† Rather Pine Island Lake, in the Hudson's Bay region.—B.

the Hamburg aquarium, and is only found on the coasts of Scandinavia. *Motella cimbria Nilss.* is common on the coasts of Northern Europe, in the Atlantic Ocean, on the west coast of Norway, in the Kattegat, on the south coast of Sweden near Bohuslän, but it is rare in the German Ocean, on the coast of Scotland, in the Frith of Forth, and on the coasts of England.

d. The following are British varieties: *Gadus pollachius L.* is found in large schools on the coasts of Europe, especially in the German Ocean, near the British coasts, near the Orkney Islands, and on every rocky coast as far as the Baltic, where it hides deep between the rocks; also on the coast of Portugal, from Lisbon to the Western Mediterranean. *Raniceps trifurcatus* is found on the coasts of Northern Europe, especially in Berwick Bay, on the east and west coasts of Scotland, in the Frith of Forth, near Ireland, especially the Bay of Donaghadee. It is rare on the coast of Cornwall and on the coast of Norway, as likewise on the Swedish coast near Bohuslän. The genera *Couchia Thomps.* and *Hypsiptera Gth.* are rare and very small sea-fish, which live in the open North Atlantic Ocean, and only visit the coasts occasionally. *C. Edwardii* was only discovered in the Moray Frith in 1866. *C. glauca* is found in the British and Scandinavian Seas near Polperro, Falmouth, and in different portions of the Channel. *C. argentata* is common from the west coast of England to the coasts of Greenland. *Hypsiptera argentea G.* is found in the open sea of the North Atlantic Ocean.*

e. The following are Mediterranean and Madeira varieties: *Gadus poutassou Riss.* is found on the coasts of Europe, in the Mediterranean, and nearGreat Britain. *Merlucius communis C.*, the common sea-pike, also called small codfish, is found not only in the North, but still more frequently in the Mediterranean. It is common from the southwest coasts of Europe to the German Ocean, especially near Scotland, in the Frith of Forth, England, and Ireland. The Bay of Galway is also called "Bay of Hakes," on account of the great number of these fish. In the Mediterranean it is very common (*M. esculentus Riss.*); also on the coast of Portugal near Lisbon, as far as Madeira; likewise on the east coast of North America. It is rare near Greenland, and is only found near the south coast; it is likewise rare near Iceland, where it is only found on the south and southwest coast. It is not found near the Faroe Islands and Finmarken, nor in the Baltic.

Fishing.—On the Nymph Bank they are so numerous that six men have caught 1,000 with lines in one night; great numbers are also caught in the Bay of Galway. It is frequently caught in the south of Norway and on the west coast of Jutland.

Motella quinquecirrata is not very common in northern latitudes. It is found on the coast of Portugal near Lisbon, near Ireland, near Portland, Brighton, on the coasts of Kent and Devonshire, in the Frith of Forth near the Orkney Islands, in the mouths of the Elbe and Eider,

* The U. S. Fish Commission has this species from off Cape May, New Jersey.—B.

near Heliogland (this is perhaps the *G. barbatus*); also on the coast of Schleswig-Holstein, in the mouth of the Schlei, the Bay of Kiel as far as Bergen, in Norway. It seems to like the deep sea where the bottom is rocky and overgrown with sea-weeds.

Motella tricirrata Nilss. is found in the Mediterranean and as far as Greenland. In the Mediterranean it is found in the Bay of Naples and near Trebizond. Near Ireland it is found in the Bay of Belfast. It is rare on the coasts of Great Britain, Devonshire, Cornwall, east coast of Scotland, Solway Frith.

Motella maculata G. is found on the coasts of Europe from the Mediterranean to Great Britain; in the Mediterranean near Sicily; in the Adriatic Sea near Dalmatia; also near Madeira, on the coast of Portugal near Lisbon; near Plymouth, Cannes, and on the coast of Devonshire.

Phycis blennioides Bl. is found on the coasts of Europe from the Mediterranean to Great Britain; in the Mediterranean near Sicily; very large near Madeira; numerous near Liverpool, Plymouth, Palperro; near Ireland, in the Axwich Bay; in the German Ocean; especially on the coast of Cornwall; Flintshire near Bowness; St. Andrews, in Scotland; in the Solway Frith. A young fish of this kind, measuring 3 inches in length, was caught at a depth of 300 feet.

Phycis mediterraneus Delar. is common in the Mediterranean near Sicily, where it is called *Mollera Figo* by the fishermen; also in the neighboring portions of the Atlantic Ocean near Madeira. It lives at a great depth, sometimes 1,200 feet, but is highly esteemed, and is frequently caught.

Gadiculus blennioides G., *Strinsia tinca Raf.*, *Molva elongata Nilss.*, are all found in the Mediterranean; *Gadiculus argenteus Guich.* is found on the coast of Algiers; *Uraleptus Maraldii Cost.* and *Haloporphyrus G.* are common to the Mediterranean and Madeira; *Mora mediterranea Riss.* from the Mediterranean to Madeira and the South Canary Islands. *Physiculus Dalwizkii* and *Læmonema Yarrellii et robustum* are found near Madeira; *Chiasmodus niger* and *Halargyreus Johnsonii G.* live near Madeira, at a depth of 1,800–1,900 feet. As with the *Saccopharynx*, the stomach of the last-mentioned fish had, in catching it, been driven into its mouth by the pressure of the air.

f. Gadus euxinus Nordm. is a Black Sea variety, which is common from the Black Sea to the Eastern Mediterranean and the Adriatic Sea on the coast of Dalmatia.

g. The following are North American Atlantic varieties: *Gadus tomcodus Mitch.* is common on the Atlantic coast of the Northern States of the Union near Boston and New York. *Brosmius flavescens Les.* is found on the Bank of Newfoundland. There are three species of *Phycis* on the east coast of America, two in North America, and one in South America. *Phycis regalis G.* is found on the Atlantic coast of the Union near New York. *Phycis americanus Stor.* is likewise found on the east coast of North America as far north as New York; and *Phycis brasili-*

ensis Kaup. is, strange to say, found near Montevideo, on the east coast of South America. The cool, fresh water of the La Plata River may be the cause.

h. The following are Pacific varieties: *Gadus chalcogrammus P.* is found near Kamtschatka, in the Behring Sea, and the Sea of Ochotsk. *G. macrocephalus Til.* is very common in the sea near Kamtschatka and America, and ascends rivers. In May and September it is common in the Bay of Avatscha. *Motella pacifica Schleg.* and *Lotella phycis G.* are common near Japan as far as the coast of North China, near Tschusa. As an intermediate variety between these two genera and the two following, we must mention a tropical genus found in the Pacific and Indian Oceans, viz: *Bregmaceros Macclellandii Thomps.* on the coast of the Philippine Islands, South China, and near the mouth of the Ganges. It is probable that the cool and fresh glacier water of the Brahmapootra and the rich vegetable food have enticed this genus so far east. *Lotella rhacinus G.*, *bacchus G.*, and *Pseudophycis breviusculus G.* are found in the south temperate zone near New Zealand and in Queen Charlotte Sound. *Gadus californicus G.* and *Gadus productus G.* are found on the coast of California as far south as San Francisco. Then we find no more fish of this kind till we reach the south temperate zone, where *Merlucius Gayi Guich.* is found on the coast of Chili.

G.—FISHERIES AND TRADE.

a. Norway.—We will only give the results of the last 5 to 6 years. In 1871 the codfisheries in Söndmöre were very extensive. Up to March 19, 4,000,000 fish had been caught, valued at $336,000. The spring codfisheries near the Loffoden Islands produced in 1870, 18,000,000 fish; in 1871, 16,500,000; in 1872, 17,500,000, and in 1873, 19,500,000; 50,000 tons, or at least 25,000 tons oil; 18,000 tons roe, or 2,000,000 fish more than in the preceding year, and about 500,000 more than the average yield of the last 14 years. The total value of the products of these fisheries stands probably alone in the history of the spring fisheries, and was $1,904,000 against $1,411,200 in 1872, and the average of $1,400,000 during the years 1859–'72. Of this sum the fishermen of Marstrand received $24,640, and the fishermen of Bohuslän, $61,600. In 1873 the Marstrand fishermen only received $24,366.72. In 1874 the codfisheries near the Loffoden Islands were not successful—only 15,000,000 fish having been caught—while in 1875 the unusual number of 23,000,000 were caught. The codfisheries near Finmarken were also successful, yielding 20,000,000—the greater portion of which were caught on the coast of East Finmarken; prices were very low, however. Near Söndmöre, Romdalen, and Nordmöre, more codfish were caught than in an average year, viz, about 6,500,000. The Norwegian codfisheries have, therefore, in the year 1875, yielded a total of 50,000,000 fish, or seven to eight million more than an average year.

b. Sweden.—The statistics are fragmentary. In 1871, 318,075 pounds of dried cod were shipped from Gothenburg.

c. Denmark.—In 1871 a considerable number of codfish were caught on the west and east coast of Jutland, and 321,000 pounds, valued at $3,360, were exported, viz, 80,000 pounds from Aalborg, 80,000 from Hjärring, 161,000 from Frederikshavn. In 1871 a great number of codfish were caught near Greenland. In 1876 the codfisheries on the north and east coasts of Iceland were successful, while on the west, and especially on the south coast, they proved failures.

d. Germany.—In 1873 the fishermen caught a large number of codfish from the mouth of the Elbe to Jutland. The Heligoland fishermen brought 650,000 pounds of fresh and 8,000 pounds of dried cod to Geestemünde. In 1874, 300,000 kilograms (661,421 pounds) of cod were caught near Eckernförde. In March, 1876, 70,260 codfish, valued at $1,750, were caught near Travemünde.

Besides these incomplete data we will give the following statistics of the North European fisheries:

Year.	Country.	Million fish.	@ 30 pounds.	Pounds.
1870	Norway	41	@ 30 pounds	1,230,000,000
1871	do	40	do	1,200,000,000
1871	Sweden			318,075
1871	Denmark			321,000
1872	Norway	40½	@ 30 pounds	1,215,000,000
1873	do	41½	do	1,245,000,000
1873	Germany			658,000
1874	Norway	39	@ 30 pounds	1,170,000,000
1874	Germany			600,000
1875	Norway	50	@ 30 pounds	1,500,000,000
Total				7,561,897,075

7,561,897,075 pounds = 75,618,971 hundred-weights, at $2.25 = $170,142,932 in 6 years, or an average of $28,357,155 per year. Count about 50 per cent. loss, and there remain still about $14,128,577 annual income from the codfisheries on the coasts of Northern Europe. All these figures are only relatively correct, as they are based on very incomplete and imperfect data—oil, glue, manure, and other minor products of the fisheries not being counted at all. Not till we possess complete fishery-statistics from all the States of Europe, can we ascertain the productiveness of systematic fishing. We embrace this opportunity to ask all superintendents of fisheries to assist us by sending reports, so that by degrees we may be enabled to give more reliable statistics of our fisheries.

e. The codfisheries near Newfoundland yielded 400,000,000 fish. In the year 1790 the English brought about 656,000 hundred-weights into the market; in 1814, already, 1,245,808, valued at £2,831,528; in 1825, only 973,000 hundred-weights; in 1835, only 712,000, valued at £356,000; and in 1848 again about 1,000,000 hundred-weights. The French, likewise, caught about 1,000,000 hundred-weights in 1848. The Americans

caught about 1,773,000 hundred-weights in 1829. In 1842, St. John's exported codfish and oil valued at $4,476,315. In 1848, the Americans caught 1,500,000 hundred-weights. Nova Scotia exported codfish valued at $786,000. Counting the hundred-weight at $2.25, and counting 3,500,000 hundred-weights, an average annual yield, Newfoundland exports $7,875,000 worth of codfish, besides oil and other valuable products of the fisheries.

III.—AN ACCOUNT OF THE LOFFODEN ISLANDS OF NORWAY.*

It is not often that we obtain a description of that remarkable group of islands on the east of Norway which our geographical handbooks mention under the name of the Loffoden, and but few of the tourists to Norway consider it worth their while to visit these rocky islands. Recently, however, we have received a very graphic description of the Loffoden Islands in a German work, which we do not hesitate to lay before our readers, as the whole work will count among the best works on Norway which have appeared in the German language. The title of the book is *Fahrten durch Norwegen und die Lappmark* [jaunts through Norway and Lapland], by G. Hartung and A. Dulk. Stuttgart. Krōner Brothers, 1877. 8vo.

The two authors have divided the work between them, the greater portion, treating of Norway, being from the pen of Mr. Hartung, which is followed by the beautiful description of Lapland by Mr. Dulk. We can earnestly recommend the work as very interesting and instructive reading, especially to those who contemplate a journey to Scandinavia, and by reproducing the description of the Loffoden Islands we shall give the reader an idea of the intellectual enjoyment which awaits him in this attractive volume.

"The closer we examine the peculiar coast formation of Norway the more will the supposition gain strength that here the ocean has covered the lower portion of an Alpine mountain range, a Cordillera with its previously-existing valleys. It is an undoubted fact that during and after the glacial period the land has repeatedly risen and sunk; but it cannot be proved with absolute certainty that during a preceding period this whole mountain range was considerably higher than it is now; nor can it be denied as absolutely impossible. Reasons, however, may be given for making this the most probable supposition.

"At present the Scandinavian Cordillera only rises to about half the height of the Alps. If, after the formation of the valleys existing at the present time, the sea had risen among the Alps to a height of 5,000 feet, what a different aspect would the valley of the Reuss, *e. g.*, present, which now shows such grand landscapes! The water would extend through the Schöllenen and past Andermatt toward the mountain passes of the Dissentis, the Gotthard, and the Furka. From the landing-place of the vessels these mountain-passes could easily be reached, while at present they are only accessible by a long and difficult road. These

* *Die Lofoten*, from Das Ausland, 50th year, No. 31. Stuttgart, July 30, 1877. Translated by Herman Jacobson.

passes would, as heretofore, be surrounded by vast mountains rising perpendicularly, and, in comparison with these, the elevation of these passes above the level of the sea would appear quite insignificant. The sea would approach these passes from all sides, through the valleys of the Rhone, the Levantine, and the Tavetsch; many other valleys would be entirely overflowed by it, while more detached mountains, like the Rigi and the Pilatus, would be surrounded by it, and thus form islands of different size.

"This is in reality the character of the fiord, sound, and island belt of the Norwegian coast. Here we really see the high Alpine passes which in our imaginary sketch we saw extending to the level of the sea, forming the low and narrow connecting links between vast sea-bound mountain ranges. As in the Alps the passes are measured by thousands, so here the so-called "Ejder" are measured by hundreds of feet. At the upper end of the Ofoten fiord an "ejde" between mountain ranges 3,000 feet in height forms a mountain pass 800 feet above the level of the sea; between mountains of 4–5,000 feet the Tamokvand "ejde" rises to a height of 550, the Balsfiord "ejde" of 200, and the Lyngs "ejde" of only 150 feet above the level of the sea; and more is not needed to show the transition from "ejde" to sound. Here the level of the sea has risen higher, and the moment the traveler leaves his vessel he steps on high mountain sides of the ancient Scandinavian Cordillera.

"The combined island groups of Vesteraalen and the Loffoden are thus in reality a branch of the great Scandinavian mountain range partly flooded by the ocean. The rising floods entered the valleys, approached the mountain passes, and covered some of these entirely, so that many became low "ejder" while others became sounds. For thousands of years the breakers have exercised their destructive influence along this coast, until finally the mountain ranges became only very loosely connected, or entirely torn from each other like shreds. In examining a tolerably good map of Norway, the strange and fantastic outline of these islands will indicate very correctiy the torn character of the mountains; and any one visiting these islands will find that the reality comes fully up to the preconceived idea. The steamer traverses this strange island-world; now it leaves a sound and circumnavigates an outer island, and before us extends the illimitable ocean in all its grandeur; now it turns again toward the coast, the sound becomes narrower and narrower till at last it seems entirely closed, when, turning a corner, a narrow channel discloses the entrance to another and broader sound.

"The rugged mountains present themselves to view from every side; we also get a glimpse of the northwest coast of the Loffoden Islands looking toward the open sea, and losing themselves in the hazy distance we see the long rows of promontories. In Vesteraalen, forests cover the lower slopes in many places; in many parts of the coast one farm

surrounded by meadows and fields follows the other, or, separated by wild and gloomy rocks, they seem like fresh green oases among the rocky desert. But in the Loffoden nothing is seen but the bare rocks, with fishing villages close to the shore; here the rocks rise high into the air like sharp saws, like crenulated walls, peaks, and cones; vast walls of rock rise abruptly from the sea; the rich variety of forms is interesting in the highest degree, and fantastically shaped rocks powerfully engage the imagination of the traveler. There the rocky promontory seems adorned with the gigantic statue of an old Norse warrior, some Harold or Olaf; with low helmet and long flowing gown he stands there leaning on his sword, the very expression of self-confident strength. In another place we see, on a giddy height, two rocks strongly resembling a loving couple, the shepherd with his shepherdess. There again a giant seems caught in the narrow fissure of the rock, making furious endeavors to free himself from his captivity; and often we meet with rocks strangely resembling a monk, who with his hood pulled over his head climbs up the steep rocky walls. All these wonders, however, are thrown in the shade by the wild romantic shores of the Raft Sound.

"Leaving the broad expanse of water which separates Vesteraalen from the Loffoden Islands, the steamer, passing between numberless low rocky islands, reaches the mouth of the Raft Sound, which separates the Loffoden Islands from the large island of Hindö. Here we behold a stream which, breaking its way through vast mountain ranges, bears a strong resemblance to the Frazer River of British Columbia as it appears seen from the mouth above the first turn; even the countercurrent is found here; but we soon become aware of the fact that this is a northern Frazer; the two yachts under full sail, as following the stream they pass us, and the frame houses on the shores, tell us that we are in Norway, whose characteristic natural features cannot long remain concealed. Meadows and shrubs cover the lower portion of the mountain sides; above these, sharp rocky peaks rise high above the snowy summits, and mountain streams and waterfalls send their icy waters into the sea with a roaring noise. Here we find the genuine Norway mountains and cascades, so often seen on paintings and so easily recognized even without the names.

"Nearly all these sounds have their own peculiar currents. Who has not heard of the Maelstrom? It may not be so generally known, however, that the fishermen of these parts well acquainted with its peculiarities enter it in light open boats, and, driven by the current, cast out their nets, and only avoid it when at times it rises threateningly. Now we get a view of the wide southern portion of the sound and of the large island of Molla, which extends before its mouth. Our attention is involuntarily attracted by the remarkable mountain called the "Troldfjeld" (the demons' rock), which comes in view as we pass a steep rocky promontory on the right shore. Like a fantastic castle built by giants, surmounted by Gothic battlements, and with a cupola and two turrets

on its western end, its broad and massive façade looking north extends before us. As our steamer advances, the other wing, looking east, becomes visible, its gray rocky walls richly ornamented with silver-white snow. The roof is likewise surmounted by fantastic battlements, and it is supported by massive pillars with strange pointed excrescences. And as the steamer proceeds farther the view changes again; the vast rocky front seems torn asunder; nothing remains but the grand ruins of former splendor, and even these gradually dissolve into loosely-joined summits and peaks. But before the enchantment disappears entirely we see another and strangely-shaped rock standing by itself at the foot of the castle. There it stands like the demon of the castle; raising her face, with the regular Scandinavian features, toward heaven, she lifts her right arm, draped by her flowing dress as high as the shoulder. But as we pass on even this turns out to be nothing but a steep rock; like a dream the whole fantastic creation disappears, and nothing but the hard and cold reality remains.

"From Lödingen, on the Tjäld Sound, which separates Hindö from the mainland, a string of fishing-stations extends along the west fiord on the southeastern coast of the islands to their southwest end at Värö. The center of the great Loffoden fisheries, mentioned even in foreign papers, lies along the Raft Sound, beginning at the island of East Vaag; the first great fishing-station is Svolvär, and the most important of all is Henningsvär. Between East and West Vaag, where the Grimsö-stream begins as a broad bay, a group of small rocky islands extends before the steep coast of the southeastern point of East Vaag. Narrow sounds and deep bays afford shelter to the ships, and a fine large light house shows at night-time the way to the safe harbor. No trees and no shrubs are found on these islands; only grass encircles the lower rocks and mountains. Along the coast there are numerous warehouses; farther back there are a number of two-story houses, and a simple but rather large church painted red; all these are frame buildings, and are erected in places specially selected for the purpose. Some distance from these buildings the large guano-factory is seen, built of wood, and having two tall chimneys painted a grayish-white, with black felt roofs. Close to it there is an enormous pile of fish-heads, broad and high, resembling somewhat a stack of grain. Since the guano-factories pay from 43 to 53 cents for a hundred fish-heads they are no longer thrown into the sea, but are carefully gathered. It is estimated that every year about 20,000,000 fish are caught near the Loffoden Islands.

"Besides the above-mentioned buildings quite a number of little frame houses are scattered all over the islands. With their small windows, and their roofs of turf with low wooden chimneys, or still more frequently stove-pipes taking the place of chimneys, they can at a distance scarcely be distinguished from the ground. By exposure to wind and rain the woodwork assumes the gray color of the rocks, and the roofs begin to resemble patches of greensward.

"According to one estimate Mr. Drejer finds room in these frame huts for 3,000 fishermen, and our pilot assured us that as many as 6,000 to 8,000 live here. During the fishing season each one pays $1.60 rent (for the whole season). Some small pine woods found in sheltered parts of the islands furnish fuel, although by no means enough to satisfy the demand; peat, which is quite plentiful, is therefore used extensively. Long poles resting on high pegs are used for drying the fish, resembling very much those simple contrivances on which the fishermen on the Prussian coast of the Baltic hang their nets. But here we also find frame-works of several stories.

"Henningsvär is the largest fishing-station, and is by a submarine telegraph connected with the rest of the world.

"Wherever a suitable place is found on this steep and rugged coast, fishing-stations have been established. In some of the most favorable places a few two-story dwelling houses may be seen with outbuildings and small gardens, a few trees and shrubs giving a more cheerful aspect to the scene. But all around on the rough, uneven ground turf-covered huts are seen, resting partly on the naked rock, partly on props of wood and stone, while some appear like birds'-nests pasted on the rock. Goats, sheep, and occasionally a few cows, nibble the scanty grass growing in small patches here and there among the rocks. Rough steps have been cut in the rock, leading to the landing-place of the boats, and on a promontory or little island a light-house shows the nightly voyager the location of the fishing-station. To these places the fishermen come from the north and from the south in their open boats as early as January. Some, however, have a more convenient arrangement: they leave their boats at the fishing-stations and travel by steamer.

"Twenty thousand fishermen come to these inexhaustible seas every year; traders come here in their yachts, and everything is life and bustle. But what a life of labor and danger! A strange feeling overcomes the traveler when beholding all this activity and the thousands of human beings drawn hither for the sake of gain, regardless of all its dangers. In the darkness of the long night the fishermen enter their boats, for the brief day-time often shortened by gloomy skies would be by far too short for the work which has to be accomplished. Threatening like dark and shapeless shadows do the rocky coasts rise behind them; before them extends the vast and gloomy ocean. They disregard cold and wind as long as the waves are not too high so as to make fishing impossible. When the weather is unfavorable they stay at home; and as a general rule they understand the indications of the weather. But who can infallibly predict the weather in those latitudes and in that season of the year? Prudence and caution are not always regarded, and many a storm overtakes the daring fishermen. At the time when I was traveling among these islands by steamer the weather had been exceptionally fine for several days, the thermometer rising to

77 degrees (Fahrenheit); even while out at sea the weather was warm, calm, and sunny, and in some of the harbors surrounded by high rocks the heat was actually oppressive.

"Such sunny summer days, appreciated all the more because they are few and far between, occur in all these northern latitudes; but not so often as to make the inhabitants forget how far north they live; for the changes in the weather are very sudden. Even now the horizon began to grow dark; a black wall of clouds rose rapidly in the south over the Vestfiord, and we had scarcely reached Svolvär when a whirlwind swept along the coast with appalling fury. For about half an hour a perfect hurricane was raging, then it suddenly grew calm again, and under a cloudy sky with a moist atmosphere and an occasional drizzle the steamer continued its course, gently rocked by small waves. When we reached Reine, where massive cyclopean rocks rise above the low coast, forming crater-like cavities partly filled with snow, another whirlwind was raging. The pilot said that here was the cave of the winds, and truly when a short while after we left Reine it was perfectly calm.

"Such sudden whirlwinds coming on without the slightest premonitory sign are by no means of rare occurrence in these northern latitudes. If in the case of such a sudden whirlwind the crew do not immediately strike sail the boat is upset, and the only means of safety is to reach the bottom of the boat and to cling to it. Most of the inhabitants of these parts carry a strong knife in a leathern sheath in their belt; no fisherman is ever without such a knife. This knife they then plunge deep into the keel and hold fast to the handle. If, as happens sometimes, one of these boats is driven on the coast, the knives sticking in the keel, among them one broken off at the handle, resembling the fatal Runic characters, tell more eloquently than words could do one of those tragedies of which more than one is acted every year in those stormy seas. All along the west coast of Norway far up toward the north it is considered a rule that of three persons regularly following the occupation of fishermen one meets with his death in the waves of the ocean."

IV.—REPORT OF PRACTICAL AND SCIENTIFIC INVESTIGATIONS OF THE COD FISHERIES NEAR THE LOFFODEN ISLANDS, MADE DURING THE YEARS 1864-1869.*

By G. O. Sars.

A.—REPORT FOR 1864.

As the subject of my investigations for this year, I selected the Loffoden fisheries as being the most extensive of all the cod fisheries on our coasts, and went to the Loffoden Islands during the first days of January, in order to be in time for the beginning of the fisheries. As regards the plan of my investigations, it was my intention above everything else to make myself familiar with all the circumstances and conditions of the fisheries, so as to gain a sure foundation on which further investigations might be built. I was therefore traveling nearly all the time, and during the winter I visited most of the fishing-stations. At every place I visited I paid close attention to the manner in which the fisheries are carried on, and to the natural conditions which might be supposed to have some influence on them; I likewise listened attentively to the accounts of experienced fishermen, and considered these of special importance for me, being entirely unacquainted with these fisheries. In this manner I have gained much important information, but I have also heard many erroneous and contradictory opinions expressed. In the following report I have therefore given only what I found to be true by my own observations, or what I at any rate considered highly probable. It will scarcely be necessary to explain why I have given to my report the character of a connected narrative. It was my object during the present fishing season to obtain as far as possible a general view of these fisheries, and I therefore give the information gained in this manner in the way which seems to me to agree best with nature's laws, reserving to myself the liberty of corroborating or correcting by further investigations whatever I dare not give in this report as absolutely certain.

A GENERAL VIEW OF THE LOFFODEN FISHERIES, AND SOME PHYSICAL CONDITIONS WHICH SHOULD BE TAKEN INTO SPECIAL CONSIDERATION.

The Loffoden fisheries are of very ancient date. They are spoken of at a very early age, and seem then to have been carried on chiefly by

* "Indberetninger til Departementet for det Indre fra Cand. G. O. Sars om de af ham i Aarene 1864–69, anstillede praktisk-videnskabelige Undersögelser angaaende Torskefiskeriet i Lofoten." Christiania, 1869. Translated by H. Jacobson.

foreigners. That the Laplanders have also in former times been engaged in these fisheries, is proved by the remains of certain stone buildings erected by them, which are found in several places on the Loffoden Islands as near Svolvær. The time for these fisheries is generally the middle of winter, or the first four months of the year; therefore about the same time as our great spring herring-fisheries. It is the same instinct which urges the fish to approach the coast in large numbers, viz, the desire of propagating their species; in other words, the spawning process. To distinguish these fisheries, therefore, from those which, later in spring, are carried on on the coast of Finmarken, they are called "*gaat-fiske*," spawn-fisheries. This kind of fisheries, however, is not confined to the Loffoden Islands, but is, as is well known, carried on in many other parts of our coast; and there are many indications that the codfish approaches the coast along its whole extent, at least from Stadt, at the same time that it comes near the Loffoden Islands. The reason why the Loffoden fisheries have been so distinguished from olden times, seems not to be that the codfish approaches these islands in particularly large numbers, but rather that the locality offers so many natural advantages for the fisheries, and is at any rate better protected against the immediate influences of the ocean. It can, on the other hand, not be denied that this group of islands, by extending so far in a westerly direction, offers this advantage, that the schools of fish coming from the west can gather here easier, and, by going to their different spawning-places all along these islands, yield their tribute to man for a longer period of time than if this group of islands extended parallel with the coast.

The Loffoden fisheries proper, which are spoken of here, are carried on along the inner side, or that part of the islands looking toward the west fiord, from the farthest point of the island of Moskenas to Hindö, and sometimes still farther. Large schools of codfish approach these islands, likewise, on the outer coast every year; but as this coast is very rocky and almost inaccessible in many places, the fishing is attended with great difficulties, and would scarcely repay the trouble.

It seems to be a very important point to gain an accurate knowledge of the formation and nature of the bottom of the sea where fishing is going on; and it is very desirable that exact soundings be taken. This would not only save the loss of many implements, but would also contribute its share toward a more systematic way of carrying on the fisheries. My time did, of course, not suffice to make all these soundings. This would require the summer season, when the days are longer and the weather calmer. I shall, however, in the following, give all the information bearing on this point which I have obtained from personal observation, from fishermen, and from other persons* well acquainted with the fisheries.

* I am under special obligation to the superintendent of the fisheries, First Lieutenant Olsen, for much valuable information.

The deep sea in the west fiord, which seems to be a continuation of the deep sea of the ocean, seems to have an even, tolerably firm, clayey bottom, which, at any rate near the mouth, seems to approach much nearer to the eastern shore (the continent) than to the western (the Loffoden Islands), whilst farther up the fiord (near Skraaven) it again comes very near the Loffoden Islands. The fishermen say that the greatest depth is far up the fiord, exceeding 400 fathoms. It is probable, however, that near the continent a channel of just as great depth extends out to the western ocean. We do not, however, possess reliable information on this point, as the fishermen but rarely go out farther than a few miles from the shore.

On the Loffoden side we find this deep channel in most places bounded by an elevation rising almost perpendicularly and forming a rocky bottom. This elevation is called the "Egbakke;" nearer to the coast it slopes down again, and then rises again close to the hilly coast. If we follow this elevation in an outward direction we find it near the eastern Loffoden in the neighborhood of Skraaven and the Molla Islands at the distance of a rifle-shot from the coast, where the bottom suddenly falls 100–300 fathoms; farther west it gradually recedes from the coast till, near the western Loffoden, the distance between it and the coast is from 3–4 (Norwegian) miles. Near the outermost islands, Röst and Vœrö, soundings have been taken till far out at sea, and no greater depth than 60–80 fathoms has been found, so that the Egbakke is here probably still farther from the coast. This Egbakke, however, must not be imagined as an uninterrupted wall which at a certain distance from the coast shuts out the deep waters; for it is in many places broken by deep ravines which extend toward the coast, and which, as a general rule, seem to follow the narrow channels between the Loffoden Islands. From these ravines longer and shorter side branches go out in different directions, which in some places are interrupted by an intervening elevation, and continued on the other side. The bottom of these ravines seems in nearly all cases to be covered by a very thick layer of soft clay mixed with mud. The bottom formed by the elevations I have, as a general rule, found to be composed as follows: Nearest the coast it is invariably very uneven, forming steep terraces, often covered with a dense mass of algæ, or projecting peaks, which, when the tide is low, are more or less dry, and appear as dangerous reefs, against which the waves of the ocean dash with a roaring noise. Lower down the bottom consists more or less of sand or nullipores; and then at a depth of 50–60 fathoms we find a tolerably broad belt of a totally different character. This bottom, which is more or less sloping, is thickly covered with a layer of small, round stones, which continue to a depth of 80–90 fathoms, and is followed by a solid rock on the Egbakke, which, having risen somewhat and formed a more or less sharp ridge, often falls off perpendicularly toward the clayey bottoms below. It is natural that the sloping of the elevation will depend on the greater or less distance to the deep water. In

the East Loffoden it slopes more abruptly than in the West Loffoden, where for long distances scarcely any difference can be noticed.

Regarding the formation of the bottom farther out at sea but little can be said, as our information is very limited. Only this is known, that at a considerable distance from the coast (at least 8–12 [Norwegian] miles), it rises considerably, so that the depth of water, in many places, is not greater than on the elevated bottoms near the Loffoden Islands. This portion of the sea, which at no very distant future will undoubtedly become of great importance to our fisheries, is generally called the "ocean-bridge" (havbroen), and is said to extend at a certain distance along the whole western coast of Norway as far as the North Cape. Former investigations, however, have proved that this elevation does not form a continuous ridge, but consists of a number of irregularly-formed hills, separated by more or less broad valleys, in which, at any rate during a portion of the year (summer), some fish gather in large numbers.

Although the Loffoden Islands are considerably north of the Arctic Circle, the sea which laves them has by no means a complete Arctic character, a fact which may readily be recognized by its fauna. The cause of this is the same as that which gives to our whole country a climate which, compared with its northern latitude, must be called a mild one, viz, the Gulf Stream, whose influence in these islands is felt more directly than on most other portions of our widely-extended coast. A positive proof of this may be found in the fact that tropical shell-fruit have repeatedly been washed ashore on the Loffoden Islands, and I myself have gathered some. There is, however, another just as powerful stream, namely, the cold Polar stream coming from the Arctic Sea, which in a southwesterly direction goes along the coast of Finmarken, and which empties into the west fiord through the many narrow channels which separate the Loffoden Islands from each other. These two streams are, so to speak, engaged in a constant combat, at one time the one being more powerful and at another the other one. This must, however, not be understood in the sense that the one could either neutralize the other or hinder it in its course. Both streams possess their full power at all times, but their direction may be changed, so that at one time the Gulf Stream is stronger near the coast, while at another it is driven farther away from the coast by the Polar stream. The rule seems to be that the Gulf Stream runs at a considerable distance from the coast, where its influence may be felt far north, even as far as Spitzbergen, while the Polar stream seems in general to be nearer the coast. When the wind is northerly and easterly, or also when there is a calm, it will be found that (at any rate during winter), if we except the small changes produced by the coming in and going out of the tide, the stream has a southwesterly direction, or, as the saying is, "going out." When there are southwestern storms or so-called "sea-weather," the stream generally goes in the opposite direction.

That this is really the Gulf Stream is seen not only by its producing a considerably higher temperature (in winter it sometimes rises in twenty-four hours from several degrees below zero to as many degrees above zero), but likewise by a very noticeable rise in the temperature of the water, at any rate near the surface. I have thus, after continued easterly wind with the atmosphere several degrees below zero, found the temperature of the water near the surface not much over $+1^\circ$ C.,* while after a southwesterly wind it rose within a short time to $+3^\circ$ C. Farther down the difference is probably less marked, but it may be observed to a depth of 40–50 fathoms. In deeper water the temperature seems to keep more even, generally about $+4^\circ$ C. It is probable, however, that the nature of the bottom has a considerable influence on the temperature of the deepest water. I have found that the soft clay mixed with mud, which forms the bottom of the ravines mentioned above, develops a remarkable degree of warmth, probably by a sort of chemical process (*e. g.*, fermentation.) When the thermometer was put in mud brought up from a depth of 100 fathoms, it quickly rose to $+10^\circ$ C. The warmth of this mud was undoubtedly originally still greater, but decreased by being brought through the cold water.

I have purposely dwelt so long on these physical conditions of our northern coast, because probably we here meet with causes (currents of the sea and changing temperature occasioned by them, and nature of the bottom), which have a decided influence on the fisheries, and consequently ought to receive constant attention by continued investigations.

I now proceed to my subject proper, viz, the fisheries. We may here distinguish three principal phases, viz, the coming-in of the fish, their spawning, and their going out, all of which are of such importance as to deserve a separate chapter.

THE COMING IN.

Very early, according to information given me by fishermen, even before Christmas, there are signs of the codfish approaching the Loffoden Islands. About this time an unusual number of other small fish gather on the higher places of the bottom, among them some which generally are found only at a very considerable depth. Soon large codfish begin to make their appearance, and as their number increases, the other fish decrease gradually, until scarcely any other fish but codfish are found.

This early codfish is called the "announcing fish" by the fishermen, and differs according to all accounts from the real codfish, which does not make its appearance till the middle of January. Although I have had no opportunity to investigate this matter, it seems quite probable

* Degrees of the Centigrade scale can readily be reduced to Fahrenheit by means of the following formula: x° Fahrenheit Centigrade $= 32 + \frac{9}{5}x^\circ$.—(TRANSLATOR.)

that these schools of codfish which come early belong to a distinct variety, which, differing in this respect from the codfish proper, stays far out at sea all the year round, and is by the approaching masses of codfish driven toward the coast. From what I could learn from the fishermen, it seems certain that some of these fish, by their peculiar color and thicker body, show a great similarity to the coast variety of the codfish found along the whole coast of Norway. But, on the other hand, it is certain that the fishermen, when speaking of this fish, also mean the codfish, and although it makes its appearance in the beginning of January, it does not differ from the codfish proper in any essential points. The only distinguishing mark of this codfish is said to be, that the skin covering the inside of the abdomen is white, while in the codfish proper it is dark. This mark seems, however, to be confined to individuals, for I have among the so-called announcing fish, which the fishermen called codfish, found some with a dark abdominal skin, and during the fishing season codfish proper with a white skin.

The coming in of the fish, which may be said to begin in January, generally lasts during all of February till the middle of March. The fishermen say that the codfish come in till the 12th of March, but it is of course impossible to fix an exact date. There are many circumstances which may either retard or accelerate the coming-in of the codfish, so that one year it may end sooner than another. The general experience has been, that after a southwesterly wind and mild weather following it, the fish come in quicker than after northerly or easterly wind and cold weather. The cause assigned for this is, that the sea has larger waves during a southwesterly wind, and the current going toward the coast drives the fish in the same direction. This theory, however, can only be accepted conditionally. To judge from what we know about other fish, the contrary might be expected, as it is well known that not only the salmon, but also several salt-water fish, as the mackerel, seem to take special delight in going against the current and wind. The real cause, I think, must rather be sought in the considerably higher temperature of the deep water, which in the above-mentioned kind of weather is communicated to the water near the surface.

The codfish do not come near the coast in one great mass, but always in schools, which, small in the beginning, gradually increase in size until they assume such large dimensions that they are called "fish-mountains." During good fishing seasons this expression does not seem an exaggeration. I have been assured that the codfish are often so closely packed, to a height of 20 to 30 fathoms above the bottom, that the fishermen who use lines can notice how the weight before it reaches the bottom is constantly knocking against the fish.

It often happens that although it is known that great masses of codfish, so-called "fish-mountains," fill the sea at certain places, none can be caught either with seines or lines. The fishermen say that the fish at such times keep entirely quiet, with their heads downward. Noth-

ing but the arrival of a new school brings life into these masses of fish and drives them forward, and a great many are caught.

This "keeping quiet" of the codfish, regarding which the fishermen have very strange notions,* seems more particularly to take place during continuous cold weather with easterly or northerly wind, and is probably occasioned by the lower temperature which through the cold and the current flowing from the north to the south is communicated to the upper portion of the water which the fish must pass in order to reach the elevated bottom. It is a well-known fact that the salmon, before entering upon their regular journey up the rivers, stay for some time near the mouth, seemingly to get accustomed to the cold fresh water. It is very probable that the codfish does something similar. As the codfish come from a great depth where the temperature seems to be very even all the year round, they are probably very tender as regards a change of temperature. And, going towards the elevated bottom they must frequently pass portions of the sea which through the influence of the Polar Stream are quite cold. It seems natural to me that the fish do not enter these cold places as quickly as when the temperature has again become higher through the influence of the Gulf Stream. It is said, however, that there is a period when independently of the changes of temperature the codfish keeps very still, viz, immediately before spawning. It is likewise probable that the codfish have been outside the great elevation (the "Egbakke") for some time before this coming-in commences, or that they follow it for some distance until they find a suitable place for getting nearer to the coast. It is quite probable (although nothing definite is known regarding it) that they select places where the "Egbakke" is low or where it is intersected by clayey ravines. It is certain, however, that during their coming in they are guided by the formation of the bottom, and that coming from the deep they follow as far as possible the deep places, *i. e.*, the ravines. As a general rule they do not follow the middle of these ravines, but the edges, being guided by their many curves and turns.

Although the codfish is a genuine bottom fish, it does not keep near the bottom all the time, but keeps considerably above it, at any rate in certain localities, as the East Loffoden. The fishermen know this very well, and, where the current is not too strong, they like to use wooden or glass floats so as to keep the nets or lines some distance from the bottom. This is especially done with the lines, both ends being fastened to a float so that only the middle portion reaches near the bottom, while the remaining portion gradually approaches the surface. As the hooks baited with herrings are very close together, the fish will, at whatever distance from the bottom it may be swimming, meet some of them. I have thus noticed near Svolvær, where this method of fishing

* I have thus found the idea very generally prevailing among the fishermen, that the codfish seek certain places on the bottom where there are said to be springs of fresh water, which they drink in order to bring the roe to maturity.

is very common, that the codfish must have been at a considerable distance from the bottom, for a great number were invariably caught near both ends of the line, while toward the middle, which is of course nearer the bottom, other fish were caught. The codfish must, therefore, have kept at a distance of 20 to 30 fathoms from the bottom. They do, however, change their position, and seem in this to be guided by various circumstances, especially by the weather. If there be continuous cold with coast wind, the current going out, which, as has been said before, always occasions a considerable fall in the temperature of the sea-water, the codfish generally keep nearer the bottom than during southwesterly or so-called sea-winds. I have often had an opportunity for making this observation. When I made my observations near Svolvær, the weather was very changeable, there were frequent westerly storms, and the temperature of the sea-water was tolerably high, viz, near the surface between + 2° and + 3° C., and at the depth where the codfish were supposed to be it was + 3° C. During my stay on the Raft Sound somewhat later in the season, when cold weather set in, the temperature of the water at the same depth was considerably lower, viz, only a little over + 2° C., and the codfish were then much nearer the bottom. It is possible that a long-continued spell of cold weather will hinder the codfish from coming in, keeping them farther away from the coast than would be the case in warm weather.

Many other circumstances, however, may contribute to bring about this result. It is very important whether there is sufficient food in the sea, here chiefly small herring. This may be both beneficial and detrimental to the fisheries. It is detrimental if the herrings keep farther out, in which case the codfish are enticed away from their usual spawning-places hunting after the herring schools, in other words, not keeping steady on the elevated bottom; it is beneficial if the herrings are between the masses of codfish and the coast, especially where there are deep fiords. If a large school of herrings can be kept far up one of these fiords, a twofold advantage is gained: there is always fresh bait, and the codfish can be kept in a place farther removed from the immediate influence of the sea, where fishing may be carried on in nearly every kind of weather. Such a place is the East-Nœs fiord which penetrates the eastern part of the island of East Vaagö from that bay of the West fiord, which on the inner side is bounded by Skraaven and the Molla Islands, and is known among the fishermen by the name of "Hölen." Here the fisheries have some years been very productive, especially near Fölstad on the eastern side of the fiord, whither large numbers of fishermen have been attracted during the last few years. That large fisheries cannot be counted on every year, has been sufficiently proved by this year's fisheries, although some schools of codfish come here every year. I am therefore inclined to consider the food of the codfish as the principal cause of the extraordinarily rich fisheries which occur here from time to time, as well as in some other places, the Raft

Sound, the Kanstad fiord, &c., although I do not mean to say that the codfish, if its coming in was not disturbed at all, could not find its way up these fiords without this food.

The circumstance that the codfish when approaching the coast follows the herring schools proves that it cannot deny its innate greediness, even during the time when the spawning instinct is all-powerful. This greediness is, however, not quite so great at this season, as I never, among the many fish which I examined at this time, found any whose stomach contained the usual food of the codfish, chiefly consisting of large crustaceans (principally decapods and amphipods). Even among those fish which were caught in the beginning of the fisheries, and of which I opened a large number, in order to obtain from the contents of the stomach some intimation as to the favorite dwelling-place of the codfish, I found in nearly all cases that the stomach was empty and had shrunk, which shows conclusively that they cannot have taken any food for a long time. Where anything was found in the stomach, it consisted chiefly of pieces of the bait torn from the lines.

The herring with a silvery shining color must certainly have a special attraction for the codfish, for they cannot refrain from snapping at the bait, which very often is nothing but old salt herring. It is of course understood that they will snap still more eagerly after fresh bait, so that it is very important for those fishermen who fish chiefly with lines, to procure fresh bait, even if they have to get it from a great distance. This will be particularly useful if the sea at those places where fishing is going on does not contain many herrings. Fresh bait will catch twice as many fish as salt herring.

I have said before that the codfish always come in in schools, and that the last are larger than the first. Each one of these schools seems to form a separate family consisting of spawners and milters. Even among the first schools the proportion between both sexes has been very even, while with other fish this is different, the milters always coming somewhat later than the spawners, in order to fructify the eggs laid by the latter. This has its reason in the peculiar circumstances of the spawning, of which I shall say more in another chapter. The generative organs are strongly developed both in the male and female of the first codfish coming in, but they have not by any means reached their full development, which is indicated by the roe and the milt being firm, and the former, moreover, being fine-grained. The fishermen, as a general rule, consider it as a good sign, when large masses of codfish approach the coast, if the roe is still firm and fine-grained, because this indicates that the fish will stay for a considerable time on the elevated bottom.

A question which comes up in connection with an investigation of our cod-fisheries, and on which I therefore desire to dwell before proceeding any further in my report, is this: "Where do the codfish come from? Where do these enormous masses of fish stay during the rest of the year, when no traces of them can be found?" There are many different

theories with regard to these questions. I have heard the opinion advanced that during the last years a great number of codfish had been observed near the coasts of Bear's Island and Spitzbergen, and that this was the cause why the Loffoden fisheries had been less successful of late years. Some people even suppose that there is a certain connection between the Loffoden and Newfoundland fisheries, a supposition which does not need any refutation. In both these theories it is presupposed that the codfish, as likewise the herring, undertakes long journeys from distant seas, which in former times seems to have been a favorite supposition, but which later researches have proved to be untenable. It seems much more probable that the codfish as well as the herring during the rest of the year stays not very far from the coast at a great depth, which it only leaves when the growing roe and milt and the consequent desire for spawning drives it in thick schools toward the nearest coast.

The circumstance that the codfish approach our entire long-stretched coast, at least from Stat, at about the same time, seems to point in this direction. If, as some suppose, the codfish came from near the North Pole, they would appear sooner near Finmarken than further south. This erroneous idea regarding the journeys of the codfish from the Polar Sea has also led the well-known scientist *Leopold von Buch* (*Reise durch Norwegen*, "Journey through Norway," Vol. I) to make the wrong statement, that the Loffoden codfish come from the north through the narrow sound which separates the islands from each other—a statement which any one who has had anything to do with the Loffoden fisheries knows to be erroneous. Neither is the explanation given by *G. P. Blom* (*Bemærkninger paa en Reise i Nordland*, "Remarks on a Journey to the North Country") correct, that the codfish come through the sound between Röst and Værö. It seems settled therefore that at any rate the chief mass of those codfish which make their appearance on the landward side of the Loffoden Islands, comes through the large fiord between Röst and the continent, and consequently as a general rule pursues a northeasterly course.

It must not be imagined that all the codfish schools follow exactly one and the same direction when approaching the coast. To describe it graphically the directions taken by the different schools must be imagined as numerous parallel lines all going in a northeasterly direction from the great deep along the middle of the west fiord, the most easterly and the most westerly of these lines being far distant from each other. For there are many circumstances which seem to indicate that those codfish which generally appear somewhat earlier near the West Loffoden are not the same which further east approach the coast of East Vaagö, nor the same which are found still further east near the east coast of Skraaven and the Molla Islands. This is proved by the fact that large masses of codfish often appear at exactly the same time at each of these places, and that there may be good fishing at the same

time near the West Loffoden and far east near Skraaven and the Molla Islands, while scarcely any fish are caught in all the intervening space. A considerable difference has also been noticed in the size and quality of the fish caught at the different fishing stations. Near the West Loffoden the fish are generally small, while further east, near East Vaagö, they are considerably larger, and the fish caught near the East Loffoden east of Skraaven and the Molla Islands in the Raft Sound and the Kanstad fiord have always been known for their great size and their fat flesh. Even in places not so far distant from each other a difference in the fish may be noticed. Thus it is said that those codfish which are caught near Balstad on the island of West Vaagö are considerably smaller than those caught at any other place in the Loffoden Islands. The fishermen even maintain that they could notice a certain difference in the different schools approaching one and the same fishing stations, so that they could tell immediately from the looks of the fish whether a new school had come in. It will be seen from this that even if at the beginning of the fishing season there is very good fishing near the West Loffoden, one cannot with certainty count on this being the case near the eastern islands, and even if but few fish have made their appearance near the western islands, there is no reason for supposing that the fishing near the eastern islands will be poor.

The codfish which come to the Loffoden Islands seem therefore to belong to many different tribes living independent of each other in the different ravines and basins of the bottom of the sea. And, as I said before, I consider it highly probable that these basins or ravines are not very far from the coast, but generally between the coast and the so-called "ocean-bridge" (hav broen), mentioned above. I have good reasons to suppose that at any rate a large portion of the Loffoden codfish, during the rest of the year, stay at a great depth in the West fiord itself. From some of the men who used to row me about on my journeys of investigation I heard the following which seems to point in the same direction: Some fishermen who were out fishing on the West fiord, at a distance of 3–4 (Norwegian) miles from the coast, near the end of May,—consequently, long after the time when the last codfish has left the Loffoden Islands,—noticed that as soon as the bait approached the bottom something commenced to pull at it. As they were anxious to see what sort of fish would come up, and as they happened to have a line of extraordinary length, they let it go down, and soon caught a fish, which certainly was a codfish, differing in nothing from the well-known Loffoden codfish. It is true that this is only a single instance, and other fishermen have made the same experiment without obtaining this result; but, on the other hand, it must be remembered that the codfish, when living at a great depth, must live more scattered in order to find their food, and that they cannot live together in such thick schools as when they come near the coast to spawn.

THE SPAWNING.

The end of March is generally considered the time when the majority of the codfish spawn. Physical conditions, however, exercise a great influence on the spawning process; thus, it may be retarded by long-continued cold weather and accelerated by unusually mild weather. It is, therefore, difficult to set any definite limits for this time, all the more as the different schools by no means all spawn at the same time. Some schools may be spawning while others are just coming in, and long after the time when the first begin to leave the coast, there are some schools which have not yet spawned. This may easily be observed in the fish which are caught, for it is not a rare occurrence that on one and the same day fish are caught with entirely loose roe and some whose roe is as firm as at the beginning of the coming-in season. The last-mentioned fish certainly belonged to a school which had but recently come in, while the former must have been near the coast for some time, as the schools coming in first always spawn before those coming in later.

The earliest spawning which I observed during the last Loffoden fisheries was toward the end of February far up the Eastnæs fiord. By fishing with a fine net on the surface of the sea I caught some small, completely transparent globules floating on the water, which I at first took for some very low species of aquatic animals, as I was entirely ignorant of the peculiar spawning process of the codfish, to which I shall now refer. I had in former times heard fishermen say that the roe of the codfish could be seen floating in the water, and that at certain seasons it filled the sea to such an extent as to make the water appear quite thick; but as this was in such direct opposition to anything I had hitherto known of the spawning of fish, I could not but suppose that what had been taken for spawn was in reality nothing but those lower aquatic animals which (as is well known) often fill the sea. The roe of codfish I never looked for, unless brought up from the bottom. The microscopic examination of the above-mentioned globules showed beyond dispute that they were eggs, although they were too little developed to decide whether they were fish-eggs. Gradually these eggs, floating about freely, became more numerous, until, about the end of March, they filled the sea, so I could get as many as I wanted. I now succeeded in following their development step by step until the tender little fish slipped out of the shell and swam about in the water.

It is certain that these eggs were really the spawn of the codfish, and of no other fish, to judge in the first place from their enormous number, and in the second place from comparisons which I made between them and roe, which about this time could, by a gentle pressure, be extracted from spawners.

This roe did not sink to the bottom, but floated on the water like that which I had first observed. This peculiarity of the roe of the codfish, to which no parallel is found in any other fish, must be caused partly by

the absence of the gluey matter which in nearly all other fish holds the eggs together, partly by an unusually large quantity of fine oil contained in the egg, which makes the specific weight of the roe a little less than that of the water. Only when the fœtus is dead, and the egg shrinks in consequence, does the roe sink to the bottom; unless this is the case, it continues to float in the water during the whole period of its development; and even the young fish recently hatched floats about in a similar manner, with its heavy umbilical bag attached to it, which for some time supplies it with food.

This phenomenon is of great interest, from a scientific point of view, and likewise deserves special attention from practical considerations. Much which hitherto seemed entirely inexplicable in the habits of the codfish when near the coast, the great irregularity with which in different years it makes its appearance near the various fishing-stations, the long so-called "fishing-periods," when for many years it stays away from certain fishing-stations and goes to others which in former years were not considered good, the periodical increase and decrease in the total mass of fish coming to the Loffoden, and possibly many other hitherto unexplained phenomena, must be ascribed to the peculiar conditions under which the codfish spawn. It is well known that the salmon invariably seeks the river and even the exact spot where it has been hatched; and this peculiarity is not confined to the salmon, but to many other fresh-water fish.

The same instinct is undoubtedly possessed by salt-water fish also, such as the codfish, and many important data all point in this direction. One might thus expect that the codfish would, after a number of years (so far it is not yet known how long it takes the codfish to reach maturity, *i. e.*, the capacity to spawn, but, to judge from other fish, it would scarcely be more than four to five years), return to those places where they have spawned in large numbers, and that good fishing might again be looked for; but experience shows that this is by no means the case, and the cause will easily be found from what I said above. The eggs of other fish, especially those which, like the eggs of the herring, are pasted to objects on the bottom of the sea, must, during their whole development, stay in the place where they were laid, while those of the codfish become a prey to wind and weather, and are carried hither and thither by the current.

It thus happens not unfrequently, as was the case during the last Loffoden fisheries, that the greater portion of the roe is driven out into the sea by the wind blowing from the land and by the current having an outward direction, so that but little of it is seen near the fishing-stations, while at other times, when the wind blows toward the land, and the current goes in the same direction, it fills the water near the fishing-stations, and, when there is a strong wind from the south, is thrown on shore in such enormous masses as to form, so fishermen have assured me, a layer several inches in thickness. A great many young fish are

undoubtedly destroyed in this way, but this does not signify much if we consider the enormous masses which are probably lost in other ways. It seems that not only other aquatic animals but likewise the codfish themselves, when going out, destroy a great deal of the roe which fills the sea.

The latter case must therefore be considered more favorable for the future Loffoden fisheries than if the roe is driven out to sea. Although this will not directly hinder the development of the young fish, it is a great question whether the roe, when the wind again blows toward the coast, will be driven to the same place from which it came; and it may happen that it is driven to coasts which are unfavorable for fishing, so that probably the greater portion of the young fish of that year will be lost to the Loffoden. It is likewise very fortunate if the cod, before spawning, comes as near to the coast as possible, especially if the spawning go on in deep fiords sheltered from wind and current, of which there are not a few in the Loffoden Islands. The question might even be raised, if nature might not be assisted in this respect, so as to prevent the occurrence of unfavorable years, which exercise such a depressing influence not only on those specially engaged in the fisheries, but on the whole country. I here refer to the artificial hatching of fish. It is not a new idea to apply this successful discovery also to salt-water fish, for it has been mentioned and discussed more than once, although the difficulties in the way of carrying out the idea have been many and seemingly insurmountable, difficulties chiefly occasioned by the manner in which the spawning process takes place, and the great depth of water which seems requisite for the development of the eggs. Nothing of the kind seems to be in the way here of carrying out this idea, so that it would be the proper locality for taking a step in this direction. The trouble would be very small, as nothing would have to be done but to place the artificially-impregnated eggs in suitable and sheltered places (I know many such in the Loffoden Islands), and then leave them to themselves.

There would be no difficulty in getting together a considerable number of eggs in a comparatively short time, considering the enormous quantity contained in one spawner. Leuwenhœk estimates that a medium-sized codfish contains no less than 9½ million eggs. A single codfish may thus produce a number of fish almost as large as that of a whole Loffoden fishing-season. During the investigations which I intend to make next year, I expect to give special attention to this matter.

Regarding the way in which the codfish acts during the spawning process, I have learned the following: After having kept remarkably quiet just previous to it, the codfish becomes restless as soon as the roe has reached its maturity. In dense schools, male and female mixed together, they will now rapidly swim hither and thither on the elevated bottoms, the females dropping the eggs and the males the milt. This spawning process of the codfish is as a general rule not going on at the

bottom, but at a greater or less distance from it, which can easily be inferred from the manner in which the fish are caught in the nets.

Reddish spots, looking like inflamed places, which are always found on the belly of the spawner after spawning, indicate, however, that the fish occasionally go to the bottom, probably to rub against stones so as to aid the roe in coming out. That the spawning does not go on all at once, but that it takes some time, may be seen from the fact that the eggs toward the inner end of the roe-bags are far less developed than those near the outlet. How long a time it takes I have not yet been able to find out, but probably several days.

During the time which elapses from its first approach to the coast till the spawning is finished, the codfish gets very lean, partly in consequence of its taking but little food, partly in consequence of the spawning itself, which always weakens fish. Its greediness after the spawning is over is therefore very remarkable. I have been told that the codfish about this time not only swallow medium-sized fish, but also the entrails of fish thrown into the sea by the fishermen with the heads of the fish yet hanging to them. In some cases the heads have been so large that it could not swallow them, and they stuck fast in its jaws. In connection with this I will mention the idea quite prevalent among the fishermen, that the codfish before it goes out to sea fills its stomach with stones, or, as they say, "takes in ballast, because by losing so much roe, or milt, it has become too light for undertaking its long journey to the deep waters." Improbable as this sounds, there may after all be some cause for it. It is quite possible that the famished codfish in its greediness has occasionally swallowed stones along with aquatic animals sticking to them.

After the spawning is over, the codfish do not stay very long on the elevated bottoms, but hasten to get to their usual places of sojourn, there to find the food which they require after the long period of fasting.

THE GOING OUT.

This phase of the Loffoden fisheries is likewise of great importance, and it has often been said that the best fishing has been had during the going out of the codfish. This applies as a general rule more to the western islands, where the elevated bottoms are more extensive than in the east, where they often form comparatively speaking only a narrow ridge along the coast. Two circumstances, however, must be taken into consideration, which have a great influence on the fisheries at this particular period. It has been observed that the codfish when leaving the coast either go in a straight line to the nearest deep, and this is unfavorable to the fisheries, or that they go along the western elevated bottoms. In the latter case the fisheries near the western islands may be very productive, as the schools may be followed from one fishing-station to the other, and large numbers be caught before they reach the deep.

The weather has likewise a great influence on the conduct of the codfish during its going out. With steady coast-wind, accompanied by cold weather, the codfish chooses the shortest way to the deep; and if the contrary is the case, it likes to follow the westerly elevations of the bottom. It is highly probable that the temperature of the sea-water, which is naturally dependent on the weather, has a good deal to do with this.

Although the codfish have been observed to keep much higher in the water while going out than while coming in, it is probable that they nevertheless go very much according to the formation of the bottom, even if they do not follow exactly the same way they came. It has thus been observed that where they have gone up very deep fiords, they followed one side of the fiord in coming in, and the other in going out. On this circumstance, together with the peculiar formation of the bottom, the very rich fisheries depend, which in certain years occur during the going out near the fishing-station of Fölstad on the eastern shore of the Ostnasfiord.

The clayey ravine, 100 fathoms wide, which at the mouth of the fiord occupies nearly its whole breadth, is divided into two branches almost opposite Fölstad; these two branch ravines surround an extensive stony bottom lying in the middle of the fiord, and run very near the eastern and western shores, which they follow for a considerable distance, till farther up the fiord they are interrupted by a shallow ravine (only 6 to 8 fathoms deep) stretching obliquely across the fiord at its narrowest place. The inner portion of the fiord forms an isolated basin, which in its eastern part, near the fishing-station of Liland, is 60 to 78 fathoms deep. This part, called Lilandspollen, is known as an excellent fishing place, and is one of the principal spawning places of the codfish.

When the spawning is over, the codfish go again across the oblique ravine, but nearer to the eastern shore, following the deep east ravine in a southerly direction, and gather in large masses near the peninsula of Fölstadland, which stretches far out into the fiord. When going out, the codfish seem to be in a much greater hurry than when coming in, and there has never been an instance of their keeping perfectly still for any length of time during their going out, while this is a common occurrence during their coming in. This period of going out is the very time when there is the best fishing, and in a few days as many fish are caught as during the rest of the fishing-season.

Nets have proved particularly useful at this season, and might even be used more extensively, as not the least injury to the future fisheries may be apprehended from them, while the case is very different during the period of coming in.

Regarding the further fate of the tender fry, I have not been able to learn much. After the young fish have left the eggs, they have no control over themselves, but are driven hither and thither by wind and waves. Only after the umbilical bag has disappeared, and the fins have

become more developed, do they make voluntary motions. It is not known what becomes of the large number of young fish which are hatched here every year. It can scarcely be supposed that they keep near the land, as the fishermen have never seen any during the spring and summer. It is possible they keep at a considerable distance from the coast, and perhaps they follow their parents to the great deep as soon as they are able to use their fins.

B—REPORT FOR 1865.

As the Department of the Interior has requested me to report as soon as possible on the practical and scientific investigations of our cod-fisheries made by me during the present year, so that my report might be laid before the "Storthing" (Norwegian Parliament), I will endeavor to give a brief account of my activity during the last Loffoden fisheries, as well as the short time which I have at my disposal will permit, before I meet the commission at Trondhjem.

Already during my last sojourn in the Loffoden Islands, I soon became convinced of the difficulty of my task, and likewise of the vast extent of the field for thorough investigations which was opening out before me, and as the whole question had aroused my deepest interest, even the greatest difficulties have not deterred me, but have on the contrary urged me to do everything in my power to have light thrown into the darkness which is still resting on many portions of the life and nature of the codfish during its sojourn near our coasts. It is my firm conviction that a great deal can be done in this direction, although the practical results which should form the ultimate object of all these investigations can in the very nature of the case not be obtained immediately. Although the first results will principally benefit science, we must not give up the hope of obtaining practical results. It is certain that most of our modern discoveries have only reached their great importance for practical life by a series of scientific researches; and it is just as certain that the practical results which we confidently hope to reach with regard to the question of the cod fisheries will only be fully appreciated when they are based on a firm scientific foundation.

The first thing to be done is, undoubtedly, to gain a most accurate knowledge of the nature and mode of life of the codfish. Only after this knowledge has been gained much of that darkness will disappear which is still resting on the migrations of the codfish; and their seemingly irregular appearance now in one place and then in another, their disappearance, their return, &c., will be found to be dependent on certain fixed laws of nature, which to know beforehand will be of the highest practical interest.

I have already, during my last sojourn in the Loffoden Islands, given some attention to this matter, endeavoring to get some light, but so far I have not yet obtained that knowledge which is necessary for leading

to really important results. My object, then, was merely to get as far as possible a general idea of the fisheries as a starting point for future investigations, and I have endeavored in my last report to give all the information which I gained in a connected form. I soon became convinced that in order to successfully carry on these investigations a systematic plan had to be followed, so as not to scatter attention over too many points and make the investigation superficial.

This year I selected the latter part of the fishing-season for my investigations, intending to give special attention to the spawning in all its relations, because this phase ought naturally to be the first object of an investigation, and because already, during my last stay in the Loffoden Islands, I had become convinced that it presented many peculiar features which deserved a more thorough examination. This is the season when the young fish come into existence, the same which in a few years will return to the same place as full-grown codfish. An opportunity is thus offered of observing the codfish during the earliest stages of its existence; and although a considerable period elapses between the time when the young fish leave the coast and the time when they return to give birth to myriads of fish, I consider it possible that if we only get a correct knowledge of this fish during the earliest and last stage of its existence, we shall be better able to draw conclusions regarding its place of sojourn and mode of life during that period when it entirely eludes our observation.

In order to be on the spot early enough to witness the spawning process from beginning to end, I left Christiania near the end of February and arrived in the Loffoden Islands in the beginning of March, therefore before the period when the spawning generally commences. I had thus an opportunity of witnessing the coming in of some of the fish, and found several of my last year's observations corroborated. From information obtained immediately after my arrival regarding the former and the present condition of the fisheries, I could see that this year they were of a very peculiar character. While in other years the coming in may be said to have come to an end about this time, it had this year scarcely begun in full earnest, as the chief mass of fish had not yet assembled on the elevated bottoms. I soon found that the cause of this delay was the unusually cold and calm weather which had prevailed in these regions for a considerable time. During the continued coast-wind the temperature of the sea-water had become unusually low, even down to a very great depth. Immediately after my arrival at the fishing-station of Henningsveer, I made observations, and found that the temperature of the water near the surface in the Gimsö current was only $+1.2^\circ$ C., and that even as far down as 100 fathoms it was but little higher.

In consequence of the coldness of the water the fish kept at an unusual depth and far from the coast, and very few of them had crossed the ridge (the "Egbakke"). That there was a large number of them on

the other side only waiting for a change of temperature to cross the ridge was sufficiently proved by the rich hauls which some fishermen made whose lines or nets extended exceptionally far beyond the ridge. I had thus a complete corroboration of the opinion expressed by me in my last report, that the temperature of the sea-water has a great influence on the fisheries.

As soon as the weather changed, the fish came upon the elevated bottoms in enormous masses, and everywhere rich hauls were made with all sorts of fishing-implements. The so-called "fish-mountain" which entered the portion of the sea between Skraaven and Svolvær seems to have been enormously large, to judge from the endless quantity of spawn.

Some time after this, I found, on a calm day, that whole part of the sea covered with a thick layer of floating spawn in various stages of development, so that with a large gauze net I could have taken tons of it. I obtained a quantity of eggs for the purpose of making further observations, and, in a few days, I saw, to my great joy, that my glass jars were full of codfish-fry. By changing the water, I kept them alive for more than two weeks, during which time they had completely lost their large umbilical bags. After this time, however, one after the other of the little fish died, probably from want of the necessary food. But as it was my intention this year to study the development of the codfish from its earliest stages, this being the first step toward obtaining a thorough knowledge of the natural history of this fish, I could not rest satisfied with this first experiment. The earliest stages of the development of the egg I would only be able to observe by artificial impregnation. I therefore obtained some mature eggs of recently-caught fish, placed them in a glass vessel containing sea-water and mixed with it a small quantity of milt. Microscopic observations proved unmistakably, after only one hour had elapsed, that nearly all the eggs had become impregnated.

I continued my observations from hour to hour, and could thus observe the minutest details of the many remarkable changes which the egg undergoes until the fœtus begins to show itself. After eight days, the outline of the fœtus could be seen distinctly in the eggs, and after eighteen days, I had the pleasure to see the tender little codfish come out of the eggs which I had impregnated. I have accurately studied this whole development, and have laid my observations before the Association of Science, accompanied by drawings giving every stage of the development on a magnified scale. By request, I have also exhibited some of the principal drawings at the fishery exposition in Bergen.

My careful observations of the development of the codfish-eggs have been made not exclusively with a scientific object. These practical and scientific investigations of our fisheries, which have been made through the liberality of our Storthing, have brought to light a very important fact regarding the propagation of the codfish, which is not only of

great scientific interest, but which may also lead to highly important practical results. I here refer to the remarkable fact mentioned already in my last report, viz, that the eggs of the codfish are not laid at the bottom of the sea, but that during the whole period of their development they float about near the surface of the water. As an unavoidable consequence of this circumstance, enormous masses of eggs are either destroyed by the waves, or washed ashore, or driven to distant places by the current and the wind. If it were possible to assist nature by directing large masses of eggs to places where they could be safe from the hurtful influences of wind and waves, a just hope might be entertained that this would prove a decided benefit to the future of the fisheries. The main object would be not so much to increase the number of fish as to confine the fish to certain localities specially adapted to the fisheries.

The well-known Swedish naturalist, Nilsson, has already spoken of the possibility of successfully applying pisciculture on our sea-coasts, and as he is certainly an undoubted authority in all such matters, I shall quote his words. In the introduction to his "*Skandinavick Fauna*," vol. IV, part 3, he says, on page 32, after having mentioned the various methods of artificially hatching fresh-water fish:

"If any one were to ask me whether artificial hatching could with advantage be applied on our sea-coasts, *e. g.*, to the herring, I would unhesitatingly answer in the affirmative. Since artificial hatching has been so successful in fresh water, it should certainly also be tried on the sea-coast, Lund's method being probably the best for the purpose. Since it has been proved that, following its instinct, every fish goes to spawn to the place where it was born, no fear need be entertained that this artificial hatching would only prove a benefit to some other coast."

The reason why, so far, no experiments have been made in this direction, must be found in the prejudices which are always opposed to anything new; but it must be said that there have also been other difficulties in the way of carrying out this idea, chiefly the way in which the eggs are generally laid, and the very considerable depth which often seems to be an essential condition of their successful development. These difficulties, however, are not met with in the hatching of the codfish-eggs. The experiments made by me this year have proved that codfish-eggs may be artificially impregnated and hatched even under the most unfavorable circumstances (I used, *e. g.*, common glass vessels containing sea-water); it is, moreover, very easy to obtain in a very short time enormous quantities of codfish-eggs impregnated in a natural manner, as they float freely in the water.

During my observations of the development of the codfish I have learned the following, which, in connection with what has been said before, may deserve attention from a practical point of view:

1. Only those eggs are fit for impregnation which, by a gentle pressure, may be squeezed out of the belly of the codfish; by pressing hard it often happens that eggs come out which outwardly look as if they

were mature, but which, seen under the microscope, appear to be surrounded by a thin covering, which contains the blood-vessels necessary for the life of the egg, and which would prevent the fructifying parts of the milt from entering the egg.

2. Eggs, taken not only from live fish but likewise from such as have been dead for a short time, will retain life and may be successfully hatched.

3. When the egg has reached a certain stage of its development it is not so tender, and can stand a good deal of outside influence. I have thus seen eggs successfully hatched which were entirely mouldy on the outside.

4. The above-mentioned principle also applies to the young fish which have just come out of the eggs. As long as they have the umbilical bag they can live a remarkably long time in impure water; but as soon as this bag has disappeared they become more tender, and as soon as the gills have developed they will very soon die when placed in impure water.

5. The whole development of the egg does not occupy half the time required for the salmon-egg. Even when the temperature is very low it does not take more than eighteen days, and when the temperature is higher it even takes less.

6. Experiments have proved that by artificial impregnation nearly all the eggs have become fit for hatching. When we remember that every individual female codfish can on an average produce 9,000,000 eggs, it will be seen what an enormous number of productive eggs can be procured in a short time and without any great trouble. From what has been said before, it will also be seen that the impregnated eggs of the codfish can be conveyed to a considerable distance without losing their capacity of developing.

Although I am of opinion that this matter is important enough to deserve our full attention, I consider it premature as yet to make direct propositions for carrying out the principles above mentioned on a large scale. Most people will laugh at the "foolish" idea of artificially increasing the number of fish in the vast ocean. But then people in the beginning laughed at the idea of artificially raising fish in our lakes and rivers. The results obtained are, however, already so great and palpable that even the greatest scoffers and skeptics have to give in to the irresistible force of facts. For the present I can do nothing but point to the above-quoted words of the famous Swedish naturalist, and in what I said I only endeavored to show that none of the difficulties which are in the way of artificial hatching are met with on our coasts, as far as the codfish is concerned, and that, on the contrary, the idea seems quite practicable.

In my investigations concerning the development of the egg, I likewise learned to understand certain phases of the spawning process, which formerly seemed to me quite inexplicable. It has thus been

proved by the experience of many years, and as far as I am concerned by my own personal observations, that during the spawning process the spawners are nearer the surface than the milters, and these latter never come to the elevated bottoms after the spawners, but frequently before them. With other fish the reverse is the case. The cause of it is the strange circumstance that both the roe and the milt of the codfish always float towards the surface of the water. The heaviest part of the egg, which is the very point where the fœtus begins to develop, and where the small opening is found through which impregnation takes place, consequently always is turned downward. In order that impregnation may take place, and the tender sperm contained in the milt may enter the opening in the egg, it is necessary that the sperm should approach the egg from below and not from above; and it is likewise necessary, if impregnation is to take place, that the milt should be secreted at the same time as the roe or before. With other fish whose spawning process has been made the subject of investigations, both roe and milt sink to the bottom, and that part of the egg which in the codfish is turned downward is here turned upward, and the male fish must therefore wait until the female fish have laid their eggs, when they take their place and pour their milt over the eggs. The observations made by me this year have, however, convinced me that the codfish is not the only exception to this general rule; for, as far as I could observe, the spawning process of the haddock (*Gadus æglefinus*) is very similar to that of the codfish, and in the Loffoden Islands takes place about the same time; and later I obtained, by means of a fine gauze net, roe of three different kinds of fish, which was floating about near the surface.

During a zoölogical excursion which I took this summer along our Southern coast, I was fortunate enough to witness the mackerel fisheries, which were going on at this time. I here met with similar facts. The mackerel, which about this time approach the coast in dense schools in order to spawn, do not lay their eggs on the bottom. Their eggs, which have a beautiful clear oil-bladder at their upper end, are easily recognized, and float about near the surface of the water exactly like the eggs of the codfish, driven hither and thither by wind and waves. I also here found eggs of different other fish floating about, and I succeeded in hatching some of these, without, however, being able to ascertain to what kinds of fish they belonged. From all these observations it seems to be clear that these peculiar features of the spawning process, at least as far as sea-fish are concerned, are rather the rule than the exception.

I had intended to make further investigations of the spawning of the codfish, but was unfortunately prevented by the fearful and continuous gales which soon after my arrival visited our Northern coasts, and which, with scarcely an interruption, lasted all during the following month, doing great damage to the fisheries, as the fishermen were prevented from reaping the rich harvest which under favorable circumstances would certainly have come to them. I felt sure, however, and expressed

this conviction immediately after my arrival to several persons, that the fishing-season this year would extend much further into spring than usual. Nearly all the fishermen, however, left the Loffoden Islands at the usual time, viz, the middle of April, although the sea was still full of fish. As late as the middle of May, when my stay in these islands came to an end, some people living near Skraaven caught a goodly number of fish with lines at a very short distance from the coast, and among the female fish caught by them there were some which had not yet begun to lay their eggs, which had not happened within the memory of any living man so late in the season.

I considered it of the greatest importance to follow up the development of the young fish as far as possible, and I greatly desired to make the necessary investigations. Even during the last days of my sojourn in the Loffoden Islands the sea was full of young fish, and wherever I cast out my fine net I was sure to catch some. But on account of the spawning process being retarded this year, these little fish were not much more developed than when I left the Loffoden Islands last year, which was a month earlier.

It was not possible for me to extend my stay, as the sum of money placed at my disposal by the government is not very large, and would not allow me to finish my investigation this year. But as the whole matter is of great importance, I hope to be able to continue my investigations next year at the point where I left off this year, and thus follow the young fish through all the phases of its development, until it leaves its birth-place.

As regards the prospects of future fishing-seasons, I consider them as exceedingly favorable. The steady south and west winds which prevailed all during the spawning-season have probably driven a great portion of the eggs far up the west fiord, where we hope that they will develop undisturbedly; and thus after a number of years there would again be good fishing near the old but now mostly-deserted fishing-stations east of Skraaven and the Molla Islands. This would prove a great advantage to the Loffoden fisheries, as the sea near these stations is much better suited for fishing than farther west.

C.—REPORT FOR 1866 AND 1867.

It was my intention in these two years to follow up as far as possible the development of the young codfish and observe its mode of life during its stay in its birthplace. This, in connection with my former investigations of the development of the eggs, I considered as the most natural beginning toward obtaining an exact knowledge of the natural history of the codfish, on which future practical investigations could then be based. My observations were made at the two fishing-stations of Skraaven and Brettesnæs, lying near to each other in the East Loffoden, as I thought it best to stick to one locality in order not to lose the thread of my observations.

In the following I shall endeavor to give a brief review of all the information I gained in these two years regarding the fate of the young codfish after it has left its embryonic state and entered upon a more independent kind of life. I shall dwell as little as possible on the purely scientific aspect of the question, as I perhaps shall have another occasion to enter upon it more fully. I shall, therefore, only mention what I consider of general interest.

In order to connect my observations direct with those made last year, I left Christiania on the 25th April, and could already on Monday, the 7th May, begin my work at Skraaven. I had chosen this place as the one most convenient for my observations, as I was still under the impression that the young codfish staid but a very short time near the coast and gradually went out into the deep. Skraaven is one of those places where the great deep of the west fiord approaches nearest to the coast, as toward the south and the east the distance to the ridge is only one-half (Norwegian) mile.

The first days after my arrival I took with my fine net a considerable quantity of floating codfish-roe from the surface of the water, all in the very last stages of development, showing that the spawning, although it had lasted till the time of my arrival, was now completely finished. Where-ever I cast out my net I also caught a number of codfish fry, both such as had recently left the eggs and were still provided with the large shapeless umbilical bag, and some whose bag had been completely absorbed, and which, therefore, had already commenced to lead an independent life. It was an unfortunate circumstance that, even when I tried to isolate them very carefully, I found them dead after a short absence from home, often in such a state of decomposition as to make any examination impossible.

During this stage of their development these little fish are so tender that they cannot exist out of the water, and that even the least touch affects them so much that they die in a very short time. This is certainly the most dangerous period in the life of the young codfish. Millions of them are undoubtedly destroyed by unfavorable circumstances, *e. g.*, storms and high waves, by getting into the breakers or being in other ways exposed to hurtful influences. It seems, however, that even at this early period they instinctively seek sheltered places. I observed on a calm, pleasant day, somewhat later in the season (the 20th May), large numbers of them near the surface of the water in the shallow sound and inlets on the east side of Skraaven, where there is a light sandy bottom. This was the first time I observed them while at liberty, for hitherto I had only been able to observe them in my glass vessels. They generally measured only 7–8 millimeters in length, and they were so transparent that I could easily distinguish them against the sandy bottom. All that could be seen distinctly with the naked eye was the disproportionately large and broad head, the eyes protruding on each side, while the rest of the body only appeared like a small fine thread vibrating continually.

As they were all swimming about on the surface of the water, I could take them up with a flat porcelain saucer and thus transfer them to my glass vessels without touching them or taking them out of the water. In this manner I succeeded in keeping them alive for some time and could subject them to a thorough examination. During the following days I repeatedly visited the same places, in order to observe their further development, and when the weather was tolerably calm I was generally successful. I noticed, however, that their number was not equally large every day; and some days I could, even when the sea was very calm, watch a whole forenoon and only catch a few. I soon found the cause of this. Whenever the fish could be seen in large numbers the sea was swarming with microscopic animals, especially those small crustaceans which are commonly called "herring food" (*Calanidæ*). In these little animals the tender young codfish found an easily digested and nutritious food, and seemed to enjoy them with great relish. By examining the contents of their stomachs under the microscope, I found this to consist exclusively of small crustaceans, chiefly belonging to two species, *Calanus finmarchicus* and *Temora longicornis.*

The warm and calm weather which continued during the following days, and the gentle easterly current, brought constantly-increasing masses of these crustaceans near the shore, and on the 12th June the sea presented a scene of animal life of which only he who has spent a summer on our western coast can form an idea. Everywhere in the sounds and inlets the water seemed thick with myriads of these microscopic crustaceans, and by taking up a little sea-water in the hollow of the hand one caught hundreds of these diminutive animals. Among them floated different kinds of medusæ, stretching out their thread-like feelers, and quickly drawing them in when a sufficient number of these small crustaceans had settled on them. But of special interest to me was the almost incredible number of young codfish which at the same time filled the sea. They might be seen everywhere from the surface of the water down to a considerable depth, appearing like dark vibrating threads eagerly engaged in snapping after the different species of *Calanus.* They had grown considerably, the largest measuring about 24 millimeters in length, and had gradually lost their embryonic appearance by which in the beginning they distinguished themselves so much from the grown codfish. The clear and undivided embryonic fin surrounding the whole body had already in part dissolved into the first and second dorsal fins peculiar to the grown fish, and even the characteristic thread-like appendage under the chin had, in the larger specimens, begun to show itself as a little projection on the lower jaw.

Up to this time I had been able to observe them uninterruptedly from day to day, and had taken note of the slightest changes which they had undergone. But now unfortunately there was a change in the weather, strong east wind and westerly current, which for a number of days made it impossible for me to get on the water. I nevertheless hoped that as soon

as the weather would get calm I would find the young codfish again in their usual places, and that consequently there would be no gap in the series of my observations; but in this I was mistaken. When at length I again visited my usual fishing places, I found the sea-water quite clear and transparent. Of the "herring-food" which formerly had filled the sea, not the least trace could be found, and with it the young codfish had likewise disappeared entirely. In vain did I examine all the neighboring sounds and inlets; not a single young codfish could I find. I began to fear that they had left the coast for good, and their appearance in great masses on the day mentioned before had been a premonitory sign of their departure, analogous to the assembling of the birds of passage before their departure for southern latitudes.

Hoping to meet with a few stragglers, I made use of the first fine day (the 23d June) for an excursion far out on the Westfiord to a distance of more than one (Norwegian) mile from Skraaven, and, after a long search, I discovered a few swimming near the surface seemingly lost from their comrades. These were the only ones I could discover, although I was on the lookout the whole day. Everything seemed to indicate that their stay near the shore was actually over, and after having searched for a few days longer I began to think of my return, convinced that I had extended my observations as far as possible. But before returning I resolved to make a last attempt and institute a search near some other fishing-station.

Several reasons induced me to select Brettesnæs, which is about a (Norwegian) mile farther north. The first few days I was just as unsuccessful as at Skraaven, and I therefore began to lose all hope of finding them again, when, on a beautiful calm day (the 5th July), I accidentally, while roving about on one of the deep inlets, discovered a young fish which was almost entirely concealed under a large medusa (*Cyanea capillata*) so that only its tail could be seen peeping forth. By means of a dipper of fine gauze I succeeded in catching the medusa and the young fish with it, and to my joy I found it really was a young codfish. You may imagine that I now scanned all the medusæ, which are very common here, very closely, and I found the same phenomenon repeated. Under most of them I found one or more young fish. These were not all codfish, however, for among them I also found another kind of young fish, easily distinguished by their shorter and stouter shape, and, on closer examination, I discovered that they were the young of the *Gadus æglefinus*, or the haddock. Only these two kinds of young fish and none else I found under these peculiar circumstances. I did not find a single young pollack under any medusa, although the sea was full of them at this time.

What can be the cause of this very peculiar relation between two such different animals? This was naturally the first question I asked. That these very tender young fish at this stage of their development should seek the medusæ, these jelly-like aquatic animals whose numberless

poisonous threads extending in all directions make them objects of terror to all smaller animals, and cause even human beings to avoid them carefully, seemed so utterly inexplicable that I thought in the beginning these fish must against their will have gotten into the power of the medusæ. This animal did, perhaps, exercise a magic power over the poor young fish similar to that of certain tropical snakes, which make little birds fly right into their open jaws. But on closer observation I abandoned this idea. These little fish were swimming about fearlessly between the numberless threads of the medusæ; they were scared away by the least noise, returning again after some time. There must consequently be something which attracted the fish toward the medusæ. Possibly they sought shelter under their large disk against other fish. This explanation seemed plausible, but was not entirely satisfactory. Careful observations have now convinced me that the young fish approach the medusæ chiefly for the purpose of catching the many small animals which constitute the food of the medusæ, and which it stupefies by its numerous poisonous threads stretched out in all directions, finally towing them up close to its disk.

Although the young fish thus deprive the medusa of part of its legitimate food, they at the same time render it a very important service which fully compensates for the loss of food. The medusa is much troubled by a parasite, a small crustacean (*Hyperia*), belonging to the tribe of the amphipods, which—often in very large numbers—cling firmly to the medusa by means of their sharp claws, and eat their way deep into its jelly-like body. I invariably found some of these crustaceans in the stomachs of the young codfish.

This remarkable relation between the medusa and the young codfish is not, however, entirely free from danger to the latter, although in many cases it affords a safe place of refuge from the persecutions of other fish. By coming too near to the disk of the medusa the small fish may easily get entangled in its poisonous threads and thus lose their life. I have found a tolerably large young codfish which had met its death in this manner.

The following days I paid frequent visits to these inlets in order to make further observations of the young codfish, and I found the locality exceedingly favorable for my purpose. Whenever the tide comes in the current brings large masses of medusæ floating on the surface of the water; and when the water is very high they are often so closely piled together that one cannot see the bottom, and I was always sure of finding some young codfish under them. These, however, were now so quick in their movements that I had to be very skillful in managing my purse-net in order to catch them. In most cases they disappeared with lightning-like rapidity as soon as they saw my purse-net, and I only succeeded in catching them when they were so hidden under the medusæ that they could not notice the first movement of the purse-net. The largest young codfish which I caught in this manner measured about 40 milli-

meters, or $1\frac{1}{2}$ inches, in length, and showed already distinct colors, 5–6, more or less, dark streaks running all round the body, while on the sides a silvery or golden gloss could be seen. Some days when the weather was very fine and calm I took excursions far out on the Westfiord, and likewise found, even at a distance of one-half a (Norwegian) mile from the coast, young codfish under the medusæ floating on the surface of the water, not only under the variety having long threads (*Cyanea capillata*), but also under the harmless disk-shaped *Medusa aurita*. Sometimes I even found them keeping quite still under other objects floating in the sea, *e. g.*, pieces of algæ, &c.

This was the extent of my observations for this year. The season was now so far advanced that I had to think of my return and defer any further observations of the young codfish till next year. I was still of opinion that the (comparatively speaking) few codfish which I had found near the medusæ were only stragglers, and that the great mass of them had gone out to the deep, not to return to the coast till they were fully matured and ready to spawn. I was very anxious, however, to reach absolute certainty regarding this matter, and even if I should fail in this, it would be very interesting to follow the further fate of these young codfish which remained near the coast, as far as possible.

The following year (1867) I left Christiania about the middle of July, and arrived near the Loffoden Islands about the time when last year I had to close my investigations. It will easily be understood that I hastened to get out to sea, as fast as possible, so that I could connect my observations directly with those of last year. I also succeeded, the very first day, when from Skraaven I was making an excursion far out on the Westfiord, in observing a few young codfish which kept under the medusæ floating about near the surface of the water. I did not succeed in catching any of them, but I became convinced that this year's fry could be observed under the same conditions as last year's, and that they were not so far developed as to leave any gap in my observations. Later, I became convinced that their number near the coast must be very large, by examining the stomachs of a number of large fish, especially the large pollack, which, about this time, were caught in large numbers.

Every one of these pollacks was crammed with young fish, often it is true in such a state of decomposition that it was impossible to decide to what species of fish they belonged, but just as often I could ascertain these to be young codfish, the only strange circumstance being that they were all considerably larger than any of those I had observed near the medusæ. This seemed to prove that the young codfish, when they abandoned their roaming life near the surface, kept nearer the bottom of the sea in order to find their food, which the medusæ did no longer supply. But as it was my object not only to study the mode of life and further fate of the codfish, but also to make them the subject of as complete and thorough a scientific investigation as was possible, observing the

least changes in their shape, color, and different organs which they still had to undergo before reaching maturity, this was not enough for me. I had therefore to find some way of subjecting them to a closer examination. But how was this to be done? The places where the pollack are generally found are all on that side of the ridge looking toward the ocean, and are consequently exposed to its immediate influence; only in perfectly calm weather I could entertain the hope of meeting with success in my investigations. The depth in these places is moreover quite considerable (at least 10-20 fathoms), so that even in the most favorable weather it would be a great question whether I would be able to catch any young codfish with the apparatus which I had at my disposal.

Resolving not to lose courage, I visited the places where the pollack are found as often as the weather permitted. I had frequent occasion to witness the playful gambols of the pollack, which the favorite poet of these northern people, Peter Dass,* has described in so simple and true a manner in his "Nordlandske Trompet" (Northern Trumpet):

> Thou gaudy pollack! I had nearly forgotten
> To sing of thy gambols and cheerful sport!
> How happy thou dancest at midsummer's time,
> When the sun shines warm, and the weather is calm,
> And nature gladdens the hearts of men.
> How often I saw thy sportive schools
> Change the shining surface to seething foam,
> And romp about in the waters!
> But alas, when thy joy has reached its height,
> The fisherman's net is approaching
> To take thee away in its gloomy folds
> And end thy sports with thy life!

I was told that the pollack found its food in these places, and from former observations I knew that this food, to a great extent, consisted of young codfish. I was much interested to see how the pollack caught the young codfish. It looked like a systematic chase, and it certainly looked as if the pollack were acting with a common and well-defined purpose. As far as I could observe, the schools of pollack surrounded the little codfish on all sides, making the circle constantly narrower, till all the codfish were gathered in one lump, which they then by a quick movement chased up to the surface of the water. The poor little fish now found themselves attacked on two sides: below, the voracious pollack, which in their eagerness often leaped high above the water; and above, hundreds of screeching sea-gulls, which, with wonderful rapidity and precision, pounced down upon those places where the pollack showed themselves, to share the spoils with them. I, of course, did not fail to make use of this chase in order to catch some of the scared young codfish; I was, however, unsuccessful in my endeavors, although I repeatedly had my boat rowed to those places where pollack could be seen, and could see how the sea-gulls caught one fish after the other at the distance of only two or three yards.

---

* Peter Dass died 1708.—TRANSLATOR'S NOTE.

This whole chase is carried on so rapidly, and the young fish stay only so short a time near the surface of the water, before they are again scattered in all directions with lightning-like rapidity, that it was not even possible for me to see any, much less catch them with my insufficient implements.

The next time I went out I took a couple of good fishing-lines, hoping to catch a pollack whose stomach might contain some young codfish in a good state of preservation, and I actually succeeded in this manner in obtaining a few well-preserved specimens, and once I even found in the stomach of a pollack, which I opened immediately after it had been caught, a live young codfish measuring eighty millimeters in length, which, when placed in a glass containing fresh sea-water, recovered rapidly and swam about in the water, so that on my return I could subject it to a thorough examination and could draw its picture.

After I had staid several days near Skraaven, I went on the 31st July to Brettesnæs, where, during the preceding year, I had noticed young codfish; I expected to find in the deep inlets large numbers of medusæ and possibly near them some young codfish, but I was disappointed in my expectations. The unusually cold and raw weather which had prevailed during the early part of the summer seemed to have exercised a retarding influence on the development of the medusæ, or at any rate to have kept them at a greater distance from the shore and at a greater depth. It was a rare occurrence to find a medusa near the surface of the water. In vain did I repeatedly and at different times of the day search all the sounds and inlets in the neighborhood; I had invariably to come back empty-handed. But I observed the same phenomena as at Skraaven; not only the pollack but likewise all the other large fish which I examined had their stomachs full of young fish, among which the codfish preponderated.

I considered it both a loss of time and an objectless waste of strength to fish for pollack in order to get young codfish, for only in very rare cases could I hope to obtain specimens in a state of preservation which would permit of scientific examination. I therefore resolved to take excursions in various directions, hoping that some chance would turn up of observing young codfish. And sooner than I had expected, such an opportunity presented itself. It was a beautiful calm day (the 3d August), and I had my fishermen take me out to the deep east of Brettesnæs, when I noticed that in a certain place the sea was filled with pieces of algæ and other objects which doubtless must have come from the shore and been driven hither by the current.

On closer examination I found that these objects floating in the sea formed as it were a continuous broad road extending parallel with the coast from the mouth of the Raft Sound in the north and following all its turns as far south as the eye could reach. A slight breeze which sprang up about this time and produced a gentle ripple on the water, let this road appear more distinctly, as the water within its limits remained perfectly

smooth on account of the fatty substances which with the algæ had collected near the surface of the water.

This phenomenon is well known to the inhabitants of this coast, and is by them called "*Strömblak*"; it chiefly occurs where there are sounds with a strong current, and it was nothing new to me. I nevertheless resolved to give more attention to it, as I thought it probable that the current might here have brought together a considerable number of medusæ and possibly in their company some young fish; and I was not mistaken.

Among the algæ I found numerous medusæ, many of which showed unmistakable signs of having lain in dry places for some time, and were consequently more or less in a state of decomposition. Nevertheless I found among them some few that were strong and healthy, and I soon discovered under them several young codfish, of which I caught two. They were both very small, scarcely larger than the largest which I had last year found under the medusæ, so that they did not aid me much in continuing my study of the changes of form and color which the young codfish undergo. All those which I caught in this place seemed to be very young, and probably belonged to those which had been hatched last.

But when our boat gently approached the above-mentioned smooth streak I discovered large and small schools of young fish swimming about freely; they seemed to be considerably larger than the young fish I had observed this year, and disappeared quickly as soon as the boat approached them. After several futile attempts I at last succeeded in catching some in my purse-net, and, to my great joy, found that they were actually young codfish, measuring 50 to 60 millimeters in length. I could now examine them while still in a live condition, and thus supplement the observations which I had formerly made on those which had been taken from the stomachs of pollack, but which had all, more or less, been in a state of decomposition.

Now first I got a correct idea of the peculiarly beautiful coloring of these fish during this stage of their development. It is quite different from that of the full-grown codfish, and these young fish are certainly some of the prettiest-looking I have ever seen. The dark cross-streaks which had already showed themselves on the larger of those young codfish which I had caught last year, had now dissolved into 3–4 parallel lines of square spots of a more or less bright reddish-brown color, which contrasted beautifully with the light color of the body, resembling a chess-board in the regularity of their arrangement. The sides and the head showed an alternating silvery or golden gloss. The characteristic thread-like protuberance under the chin had now become fully developed, as also the fins; in fact, aside from the color, these fish could immediately be recognized as codfish.

I knew now where I had to look for them in the future, and supplied myself with the necessary fishing implements. The only drawback

was that I could only pursue these investigations in very calm weather, and the following days were unfortunately anything but calm, a strong east wind prevailing all the time. But sooner than I had expected under the circumstances, another and more convenient opportunity presented itself for continuing my observations under far more favorable conditions.

One day when my fishermen rowed me along the shore in the sheltered inlets, where in lieu of something better I intended to observe the young pollack of which there were a great number, I suddenly discovered close to the bottom some young fish of about the same size, which, however, by their brighter color and their peculiar marks differed from the pollack, and in which, to my great joy, I soon recognized young codfish. I did not succeed in catching any that day, but I had now found the lost track and determined to follow it up.

The first fine day (the 23d August) I went to the place where I had seen the young codfish, of course well supplied with all the necessary implements; and I had not to search long, for all along the shore they were found in as large numbers as the young pollack. They were now so large that I could catch them with bait; and I even succeeded in catching several with a fine hook. I caught quite a number that day, and could now subject some of them to a thorough anatomical examination. On examining their stomachs I found that small as they were they could not deny the well known voracity of their species. The contents of the stomach consisted of a great variety of marine animals. Some were completely filled with young snails; one had swallowed a full-grown *Gammarus locusta*, which filled the stomach and was well preserved with all its feet and claws; another one had swallowed a tolerably large worm (*Annelide*), one-half of which had been completely digested, while the other half had scarcely entered the stomach; and it even happened once that a large young codfish which I had placed with others in a tub filled with sea-water, snapped after a smaller codfish evidently with the intention of swallowing it, in which, however, it did not succeed as the fish was too large.

The following days I visited various places in the neighborhood so as to obtain a more correct knowledge regarding the number of young codfish in these waters. In nearly all the bays and inlets which I visited I found them in very large numbers together with young pollack. They had doubtless come near the coast quite recently, for previously I had not seen a single one. In a certain sense we may, therefore, count an important period in the development of the young codfish from this time; for they have now changed their roaming sort of life to a more stationary one, or, to speak scientifically, they have from pelagic become littoral fish.

As an intermediate stage between the pelagic and littoral periods, we may consider the time when they seek the company of the medusæ. As these by wind and current are driven on the shore in very large

numbers, it may be said that they, in a manner, show the young codfish the way to the nearest coast. When measuring about 40 to 50 millimeters in length, they leave the protecting company of the medusæ to seek their food elsewhere; about this time they seem to gather in larger and smaller schools, which in the beginning, as if loath to renounce their roaming life, roam about for some time near the coast.

This appears to be one of the most dangerous periods in the life of the young codfish. They are eagerly sought after by various fish-of-prey, especially by the pollack, which arrive about this time, and which certainly destroy millions. These small defenseless young fish would therefore have but a very poor chance of reaching maturity if their instinct did not teach them to seek the quiet bays and inlets, where, among the algæ grazing near the shore, they find sufficient food and shelter from their persecutors.

After having continued my investigations for some time, I returned to Skraaven in the beginning of September. Here I likewise found young codfish all along the shore, the largest number close to the landing-places, so that by going a few steps into the water I could catch as many as I wanted. What struck me very much, however, was the circumstance that during all this time they did not seem to have grown much, although a considerable time had elapsed since I had first observed them near the shore. Only every now and then I caught some larger ones, but this was, comparatively speaking, a rare occurrence, the overwhelming majority measuring about 60 to 70 millimeters in length. I observed them day after day far into September, but strange to say their average size remained the same. They seemed to have stopped growing entirely, although one might have thought that just at this very time they would grow more rapidly, as they had plenty of food in the numberless small animals living among the algæ.

It was evident that here was a curious problem which must be solved, and after I had begun to study the question thoroughly, I soon found its solution. The fish which day after day might be seen near the coast were not, as I had thought in the beginning, the same individuals, but there seemed to be a constant emigration and immigration. If we remember that not all the codfish spawn at one and the same time, but that there may be a difference of one and even two months, it is evident that there must likewise be a great difference in the development of the young fish. It is quite probable that some young codfish which had not yet given up their roaming life, were found near the Loffoden till the very end of my stay there, *i. e.*, the beginning of October. In all probability those young codfish which I saw swarming near the landing-places must be counted under this category.

But what became of the larger and older fish? The answer to this question was easily found and its correctness could be corroborated by direct investigation. As is the case with other fish of greater size, the smaller ones are generally found near the coast, while the larger ones seek

the deep water. In order to catch larger young codfish, I must therefore seek a more suitable locality and supply myself with the proper fishing implements. By means of a tolerably large purse-net which could be let down to the depth of several fathoms, and herring as bait, I succeeded during the following days in catching some of the older codfish. When the weather was sufficiently calm and the water clear, I could easily observe them. The larger they were, the deeper did they keep themselves swimming about with their belly pressing against the bottom. Only with great difficulty I could by means of bait entice them higher up, while the young pollack both large and small were swimming about near the surface.

Thus these two kinds of fish show their different nature even at this early period. The codfish distinguishes itself from the pollack by being a genuine bottom-fish. We may also see in this circumstance the first indication of the "going out" of the young codfish. As they grow older and larger they probably gradually seek a greater depth of water, until they meet their progenitors in the great deep outside the coast. The larger young codfish which I caught in the above-mentioned manner a few days before my departure, *i. e.*, in the beginning of October, measured 120–130 millimeters, or upwards of four inches in length, and could at most be scarcely considered more than seven months old. From this time on they probably grow more rapidly, and I therefore presume that it scarcely takes more than three or at most four years till they return to their native place as full grown codfish, to give birth in their turn to millions of young fish.

In the above I have simply given a report on the history and the results of my observations during the last two years, and I shall add a few remarks. There are probably many who, after having read the above, will say, "All this may be quite interesting to read, but of what practical use is it? Does the government for those sums which are spent on these practical and scientific investigations get the value of its money?" It will be useless to argue the question with those who expected important practical results from the first year's investigations, just as if such results were ready made and only waited to be brought to light. I hope, however, that there are some persons who, from the very beginning, have looked at the matter in the right light, and who have become familiarized with the thought that practical results can only be reached by a thorough scientific investigation, and can only be considered as actual results when they rest on a firm scientific foundation. These persons will understand me when I explain to them my views of the whole matter. I consider it necessary in every extensive investigation, especially when, as in the present case, a new field has to be entered, that, first of all, the object of the investigation is fully and clearly understood; and that, secondly, a well-defined plan is followed.

To plunge at once *in medias res*, and enter upon suppositions before any firm basis has been gained, may look well enough to the casual ob-

server, and may gain fame for the one who starts some such brilliant suppositions, but this way of proceeding is, in my opinion, by no means a safe one. It is better to proceed slowly but surely even if every foot of ground has to be gained by overcoming difficulties. The knowledge obtained in this manner may truly be called a safe capital which will yield rich interest. My first object was to gain as complete a knowledge as possible of the natural history of the codfish, and I have sought to gain it all the more eagerly, as I consider such a knowledge as an important result in itself.

True to my above-mentioned determination to follow a well-defined plan in my investigations, I have, in the full sense of the word, begun *ab ovo*, with the development of the egg, and have, step by step, followed the further development and fate of the young fish during their stay in their native place. Any one who knows how incomplete our knowledge of the propagation and development of salt-water fish has been will grant that a connected series of observations of one of the most common and most important species of fish will always possess great scientific interest; and I do not hesitate for a moment to declare it as my sincere conviction that such observations are also of great practical importance, if in no other respect, at any rate because they must be considered as a necessary link in the chain of our knowledge of the natural history of this fish.

It will easily be understood that the knowledge of the development of the young codfish gained by a single series of observation cannot be complete and exhaustive. I have, to the best of my ability, endeavored to get from them as much information as possible, but I must confess that there are certain points which require a closer examination and a fuller corroboration. I therefore consider it necessary to follow the development of the young fish once more, and likewise to ascertain whether they are found under the same conditions on other points of our extensive coast. It would, finally, be a matter of great interest to follow the development of the young codfish farther into the winter, which doubtless could be done if one had the necessary apparatus.

D—REPORT FOR 1868 AND 1869.

In accordance with the plan mentioned in my last report, I started for the Loffoden in the first days of November, 1868, in order to continue my observations of the young codfish. I did not expect, however, that my observations would extend very far into the winter, as shortly before I left the Loffoden Islands last season I thought I had noticed signs that the young codfish were beginning to go out to the great deep. I considered it of great importance to follow them as far as possible, and with this object in view, I was not frightened by the prospect of having to spend the darkest and most stormy part of winter in these arctic regions.

After a long and difficult journey, I reached the Loffoden Islands toward the middle of November, and immediately commenced my investigations near Skraaven, endeavoring to make the best possible use of the short days. I found the young codfish under the same conditions as when I left, all along the shore, even near the landing places, but, although the season was much farther advanced than when I left last time, their size was about the same.

In order to find larger and older codfish I had to choose locations where the bottom declined very abruptly. The last time already I had chosen such a place and had found it very convenient for my observations. From the south a very deep inlet called "Galtvaagen" extends far inland; it is well protected from the sea and wind, and its bottom falls off abruptly on both sides; the inner portion has a flat sandy bottom, which near the coast has a rich vegetation of algæ. Here I found, both at the time of my departure last year and now, a large number of small young codfish; I therefore hoped that in the deeper places of this inlet I would find the larger young codfish on their gradual journey toward the great deep. I soon discovered in the deeper places some young codfish of considerable size, which, with their heads pressed against the bottom, were swimming around among the stones where the bottom began to rise toward the shore. These fish were, however, much more cautious than the smaller ones, and could only with difficulty be enticed to snap after the bait attached to my purse-net. As this way of fishing is rather awkward except in places where the water is shallow, I soon abandoned it, and got a fine line with two hooks baited with herring, and a few days later caught some of these young codfish. The largest measured 150 millimeters, or almost 6 inches, and were therefore considerably larger than the largest I had caught just prior to my departure last year. The young fish, scarcely half the size of the above-mentioned ones, which kept near the shore seemed meanwhile to decrease in number day by day, and it finally became a rare occurrence to see them in those places where formerly they had made their appearance in enormous numbers. These young codfish were therefore evidently going out; and as I did not catch any more of the larger ones in the deep places, I began to think that they were preparing to leave the coast for good to undertake their long journey to the unknown places far out at sea where the grown codfish live when not near the Loffoden Islands. When thinking more about it, however, I found that this could not be the case. For they would go almost direct into the jaws of the large schools of codfish which probably about this very time were approaching the Loffoden Islands for the purpose of spawning; and, judging from the greedy nature of these fish, there could be no doubt that they would not spare their own offspring, but swallow unmercifully every young fish which came in their way. I knew, however, that nature takes better care of the preservation of the species than to permit such an occurrence, and I therefore felt sure beforehand that they must still

stay near the coast for some time, and that I in some way or other would meet them once more before my departure.

After several resultless investigations made in different places, I one day (the 10th December) cast my line near a high rock called "Skarvbjerg," which rises perpendicularly from the sea, which is sheltered from the wind, and where close to the shore there is a depth of 8 to 12 fathoms. The line had scarcely touched the bottom when there was a vigorous pull at it, and on each hook I brought up a struggling young codfish. I now continued to haul them up as fast as I could go. Sometimes I caught one, sometimes two, and in a very short time I had about twenty. All of these were considerably larger than those I had formerly found near the coast, all measuring from 150 to 200 millimeters. I had now found a convenient place where in the future I could always procure young codfish, and was well contented with this day's result. But as I had set myself the aim not only to examine from a zoological point of view the changes of shape and color which the young codfish undergo during their development, but also to obtain a general idea of their mode of life during the various stages, I could not rest satisfied with this result. I must also find out whether they were likewise found in other places under similar conditions; in other words, whether these conditions applied to *all* young codfish of this size.

The investigations made by me during the following days seemed to confirm my belief that such was the case. In most places where I cast my line near the coast, at a depth of 6 to 10 fathoms I caught several young codfish of a similar size. Nowhere, however, I found them in such large numbers as near the Skarvbjerg.

On a particularly calm and fine day I therefore examined this locality more closely, if possible to find the cause of these fish appearing in such extraordinarily large numbers in this place. The water is remarkably clear and transparent at this season of the year, and in calm weather one can see the bottom at a very great depth, and I could consequently examine the place very easily on a fine day. From the Skarvbjerg the coast falls off almost perpendicularly toward the bottom, at a depth of 6 to 8 fathoms. As in nearly all the sounds near the Loffoden Islands, the bottom consists of coarse sand. At this place, however, it was for a considerable distance covered with algæ, which gave it a spotted appearance, light and dark places alternating. I soon noticed young codfish, and my observations convinced me that they must live here in very large numbers. As often as they crossed from one grove of algæ to another, their bodies were, even at this great depth, brought out in distinct outline against the light sandy bottom; and by watching one of these bright spots for some time I could see one codfish after the other, and often many at a time, cross in every direction. It was evident that here they must find plenty of food, and by examining several young codfish which I had caught here, I found this fully corroborated. Their stomachs were invariably filled to their utmost capacity with different marine

animals, especially small crustaceans, many so large that one of them filled the stomach and was lying there in a good state of preservation, with all its feet and claws. The enormous number of crustaceans was easily accounted for by the nature of the bottom and the general character of the location.

Right opposite the Skarvbjerg there are two islands separated by a narrow sound, the current coming from the ocean passing through it from three different points. These three different currents meet at the Skarvbjerg, and all the small animals brought in with the current gather here. Even later in the season the place is well known to the fishermen as a good fishing place for other fish, which, during the summer, like to come near this steep mountain.

The great variety of color in the young codfish was quite remarkable, although most of them had not yet assumed their final dark-spotted appearance, but showed on their sides on a dark background three rows of bright spots (almost as white as chalk); the color of this background varied very much, so that no two fish were alike in this respect. All the different shades of color could be observed, from bright red and yellow to a bright green or gray. A great difference could likewise be observed in the shape, some (always those having a bright red and yellow color) being thick-set, the outline of their back being strongly curved; others again having a more slender and elegant shape. I found that all these variations of shape and color were chiefly occasioned by the difference of food. The thick-set, reddish-yellow fish had chiefly lived among the algæ and had swallowed large numbers of the reddish crustaceans which are found here, while those of a light green or gray color had chiefly lived on the sandy bottom, where they had not found so much food; they were consequently much thinner. In their stomachs I found, besides a few small crustaceans, several species of worms living on the sandy bottom; in some, a few young fish, *e. g.* young *Cottus scorpio*.

During the following days I was quite busy examining these different varieties and making drawings of them, and only occasionally I took a short trip to my usual fishing-station near the Skarvbjerg, in order to procure fresh material for continuing my observations. In the course of the winter the number of fish decreased gradually, so that toward the end I could fish for hours without catching anything. The few young codfish which I caught were not much larger than the first time I found them here, although a considerable time had elapsed. The phenomenon observed by me at a previous visit thus repeated itself. It seemed as if their growth had been stopped, although the rich and plentiful food found here would rather lead to the opposite result. I knew, however, from experience that it only seemed so, and that the simple explanation was this, that the few young codfish which were still found near the Skarvbjerg were not the same as those seen here some time ago, but younger ones, which up to this time had lived some distance from the coast.

Those young fish which I had the first time found here in such enormous numbers must, therefore, have gone to other places, probably to the great deep. In order not to lose the thread of my investigation, I had therefore again to go after them. As none were to be seen in the sound between the islands, I had to make my observation farther out at sea, which at this season of the year could not be done every day. The stormy weather which set in at the beginning of the month (February) and which continued for a number of days, seemed to place an insurmountable obstacle in my way. All I could do was to wait patiently until the weather got fine again.

On the first tolerably calm day I went out, fully supplied with fishing-lines and fresh herring for bait. But I soon found that fishing here was not so easy as nearer the coast. The strong current, which, in consequence of the long-continued stormy weather was coming in from the great deep, made it impossible for me to keep the lines steadily near the bottom. Every time my boat was raised by a wave the lines were likewise raised a considerable distance from the bottom, and every time the boat sank lower the lines got entangled among the algæ, and when the boat rose again the hooks and bait were torn off.

After several futile attempts, during which I had lost quite a number of hooks, I abandoned my purpose, and returned to my usual fishing-station near the Skarvbjerg; but not a single fish did I catch here, nor could I discover any among the algæ, which, formerly had been their favorite place of sojourn, and where I had often observed hundreds of them.

The same was the case in some other places which I visited in the course of the day. The young codfish seemed to have disappeared entirely. It was evident that the only place where there would be some hope of finding them would be those very places outside of the islands, and covered with algæ, where I had been so unsuccessful. But I was convinced that, in order to succeed, I must change my method of fishing, and use implements more suited to the circumstances. I had, in the course of my investigations, so often to make similar changes, that I had become accustomed to them. I had begun to take the newly-hatched young fish from the surface of the water with a porcelain saucer; then I had used a small purse-net made of fine gauze; then a small hook tied to a thin thread; then a large purse-net; and finally a regular fishing-line. I now determined to use a stationary line, which I could set in a convenient place in the evening and haul it in in the morning, believing that I would save much time which I had formerly lost in catching young fish. I had such a line prepared and furnished with about 100 of the smallest hooks I could find.

As soon as I could procure enough fresh herring for bait, I set my line at a depth of 20 to 30 fathoms in one of the sandy bottoms, bounded on both sides by dense groves of algæ. The following day the weather was not very favorable, but for hauling in a line you need not be so particu-

lar about the weather. I therefore went out anxious to see the result of my new method of fishing. I soon noticed that there must be fish on the hooks, but I was not prepared for as large a haul as it turned out to be. On nearly every other hook there was a young codfish, and when the end of the line had come up, I was almost surrounded by fish. They were all considerably larger than those I had formerly observed in this place, their average length being about one foot. In the beginning I thought that these must be two-year-old fish, but when I afterward set my line in a shallower place I also caught smaller fish, so that I soon had all the different grades of size. The "going out" of the young codfish to the algæ bottoms had probably begun much sooner than I had expected, and some of the older fish had, perhaps, already gone out while I was still pursuing my investigations in the shallow places along the shore.

That these fish, which later in spring are well known to the fishermen by the name of "algæ-fish," are really young codfish, and not, as the fishermen generally believe, a separate species of torsk, which lives all the time on the algæ bottoms, has been placed beyond a doubt by my former investigations. These fish were, both as regards color and shape, so exactly like the full-grown codfish, that by placing them side by side there could not be the least doubt that they were the same fish at different stages of their development. Some of them, which chiefly seemed to live among the algæ, differed at first sight somewhat from the others by their plump shape and their brown and even red color, and by a larger number of the characteristic dark spots. But there was no doubt in my mind that these differences were only caused by their having chosen locations which yielded more and better food, and that, under less favorable circumstances, they would in a comparatively short time again assume their usual color and shape; for I found fish in every imaginable intermediate stage, and as regards the younger fish, former observations had proved this conclusively.

Occasionally I also caught a considerably larger fish, not much smaller than the small winter-codfish, only that the organs of generation were not yet fully developed. All these larger cod I considered to be stragglers from the generation immediately preceding this one, therefore two-year-old fish. The chief mass of the small codfish living on the algæ bottoms during spring and summer belong, in my opinion, to one and the same generation, and the very considerable difference in size is easily explained by the circumstance that they are hatched at different times (the spawning-season of the codfish lasts from the middle of February till some time in May), by the difference in the quantity and quality of their food, and likewise by purely individual causes.

Having now again found the young codfish in a new phase of their development, and having thus found the thread of my investigations, which I had almost considered as lost, the next thing for me to do was to corroborate more fully the results of my observations, and to get some idea regarding the occurrence of the small codfish in the different local-

ities. I therefore continued my line-fishing for some time in different places, and whenever the conditions were the same as when I first commenced this kind of fishing, I invariably caught large numbers of fish.

I delayed my departure until I had obtained some of the eggs, which at this time (beginning of March) were floating about everywhere, eggs which had been laid by the large schools of spawning codfish which had now come near the coast; and until I had artificially hatched some of the small, almost microscopic young fish, which during a former year had formed the starting-point of my investigations. I had thus, step by step, followed the young fish for a whole year during the different phases of its development and had thus finished one of the first and most important, and at any rate least known, chapters in the natural history of the winter-codfish. Further investigations of the growing codfish I had to defer till another year, as I had staid long beyond the time I had set myself.

During the time when I made the observations which I have briefly described in the foregoing, viz, during winter, the grown winter-codfish had come near the Loffoden Islands at the usual time, and had given plenty of employment to all the fishermen. The largest fisheries were going on at the very place where I had stationed myself, viz, Skraaven, so that for some time people almost waded in fish, liver, and roe.

Although a study of the cod fisheries themselves was not included in my plan for this year, as my time was too much occupied with the investigation of the development of the young fish, I nevertheless resolved not to miss the chance entirely of making some observations on matters which I thought might in some way be connected with my present investigation, and which formerly I had no chance of making, on account of other questions which required my undivided attention.

The first point was to examine those winter-codfish which came in first, if possible from the contents of their stomachs, to reach some conclusion as to the places where these fish staid. Of the many winter-codfish which I examined only very few had some inconsiderable remnants of food in the lower portion of their stomach. From what I found I concluded that their food consisted almost exclusively of herrings, and even in the greenish homogeneous mass contained in the lower part of the entrails I discovered portions of the gills of the same fish. In one stomach I found the whole backbone of a herring, which, by its extraordinary length, proved it to have belonged to the large sea-herring, which during the last years has during winter come near the outer coast of the Loffoden Islands and Westeraalen in enormous numbers. Many reasons led me to the conclusion that the sameness in the character of the food was not merely accidental during this year; and it is my firm conviction that the principal food of the full-grown codfish really consists of herrings and similar small fish. Its unusually bright and shining color and its strongly-developed teeth indicate a genuine fish of prey. I consider it, therefore, highly probable that the codfish

live in the same places as the herrings and similar small fish. But if we ask where these places are, no definite answer can be returned, since we do not know where the sea-herring stay during the time that they are not near the coast for the purpose of spawning. I shall have occasion to refer to this matter again, and give that opinion which I consider as the most probable.

The second point was, to examine the so-called "coming-in" fish, which in the opinion of the fishermen is different from the codfish, and which, especially in the beginning of the fishing-season, is frequently caught together with the common winter-codfish. I had already during my first stay in the Loffoden Islands cursorily examined this fish, and found that the only distinguishing mark which was mentioned, namely, that the skin of its belly was light, while with the codfish it was darker, was wanting in most instances. But as at that time I was not so well acquainted with the normal appearance of the codfish as I am now, I resolved to institute a careful comparison between the two fish, in order to arrive at some certainty in this matter. In order to do this, I had first to make myself acquainted with a number of individual codfish, and therefore selected from among the fish brought to land the most characteristic specimens, which I examined carefully, measuring them and making accurate drawings of them.

Having thus become thoroughly acquainted with the looks of the codfish, I endeavored to get specimens of the so-called "coming-in" fish, in order to institute comparisons between this and the former. The first specimen I obtained appeared to have certain distinguishing peculiarities of shape and color. The shape of the body was thicker and plumper than in the codfish proper, the head was not so pointed, and rather broader across the neck; the color likewise differed from that of the codfish proper, the main color being a distinct brownish-yellow, the number of dark spots was larger and extended farther down the sides. But what had still greater weight, in my opinion, was the circumstance that the teeth were smaller and fewer in number than in the codfish proper. The specimen which I examined had just come out of the water, and was quite fresh and in an excellent state of preservation. On opening it I found it to be an unusually fat female, with a remarkably large liver and large fully-matured roe-bags. As regards the number of rays in the fins and its general anatomy this fish was an exact counterpart of the common codfish.

With a view of still further examining this so-called "coming-in" fish, I went to a place on the east side of Skraaven, where the elevated bottom is somewhat narrower, and where "coming-in" fish were said to be found quite frequently among the common codfish.

When I arrived, the fishermen were just hauling in a net, and I therefore resolved to see what fish were in this net. The fishermen pointed out several fish, which in their opinion were not real codfish, but "coming-in" fish. Some of them were, as far as their shape and color was

regarded, exactly like the specimen I had examined; but there were some where the differences noticed by me were by no means so distinctly marked, and with many fish neither I nor the fishermen could tell to which class they belonged. Every imaginable shade of difference between the two was found, and not one of the distinguishing marks mentioned by the fishermen seemed sufficient to draw a sharp dividing line in all cases. I therefore arrived at the conclusion that the "coming-in" fish and the codfish proper were really one and the same fish, and that the peculiarities occasionally found in some of the former were owing to purely accidental circumstances, *e. g.*, food and location; in other words, I felt convinced that the young of the "coming-in" fish may become codfish proper and *vice versa.*

During these fisheries I also occasionally had an opportunity to make some other observations, which all went to corroborate some points in the spawning process of the codfish mentioned in my first report. I had thus several times an opportunity of convincing myself that the male fish, contrary to the general rule, while spawning are nearer the bottom than the female fish. Those boats which employed drag-nets almost exclusively caught male fish, while those using floating-nets caught female fish.

That the male fish must be nearer the bottom I would have declared as a necessity, even before I had found it corroborated by tangible proofs, from the nature of the matured eggs; for these are always found in such a position that the side containing the micropyle turns downward. Even when (as frequently happens in experiments made with artificial hatching) some eggs are squeezed out of a codfish which have not yet been fully matured, and are still covered with the thin skin containing the blood-vessels, they will nevertheless turn the side with the micropyle downward. It will therefore be easily understood that during the natural spawning process the male fish must be lower than the female, so the milt which is rapidly rising towards the surface may hit the only place in the egg where impregnation can take place. The build of the eggs, on the other hand, necessitates their floating near the surface. The many experiments with fish-eggs which I had made during former seasons, and likewise this winter, had proved this peculiar phenomenon beyond a doubt. If, therefore, any one in making such experiments, should find that the eggs placed in some vessel do not float toward the surface, this is either a sign that the water does not contain sufficient salt, or that the eggs are not mature, or that they have begun to decompose. Wherever this is the case, they can never be hatched. *

I must yet mention another point, which I consider of great interest, and which I found corroborated by my investigations. For several seasons I had observed, toward the end of my stay in Skraaven, that the water in the sounds formerly so clear and transparent had become thick

* I have mentioned this because I have been told that experiments with the artificial hatching of codfish eggs, made in Christiania this spring, had proved my statement that codfish eggs were always developed while floating near the surface to be incorrect.

even up to the very landing-places, and that this was occasioned by enormous masses of floating roe in every imaginable stage of development. In the beginning I thought that this roe had been brought in from the sea by the current, as the codfish farther out had commenced to spawn; but, to my astonishment, I found that the quantity of roe farther out was not large enough to warrant such a supposition. I soon found out the real state of affairs. This was the time when the fisheries were in full blast, and one large boat-load of fish after the other was brought ashore by the fishermen. It was, therefore, an every-day occurrence to see the fishermen on their return from the sea everywhere busy at work cutting and cleaning fish, taking out the entrails, the liver, and roe, finally cutting off the head, and throwing the fish on the shore or on the many boats for the purpose of drying or salting. All this was, by dint of long practice, done with an amazing rapidity and precision.

These fishermen, however, had not the least idea that by thus tending their wonted business they were, at the same time, acting as "artificial hatchers of fish." But this was really the case. By the one cut which opens the belly of the fish, a slit is invariably made in the roe-bag or in the milt, a considerable portion of the mature eggs and the loose milt flow out and mingle in the water. When the cleaning of the fish, as often happens, is going on on the strand, a good deal of the roe coming out of the fish during this process is undoubtedly lost by lying in the warm sun too long; but often it will develop, even here, if it falls into one of the numerous puddles of fresh sea-water which the going-out tide has left. These puddles then take the place of the intermediate hatching-vessels, where mature eggs will certainly be hatched and be taken by the tide into fresh sea-water, where they can develop.

I one day watched a fisherman who was cleaning fish, and, for this purpose, had selected a convenient place close to a small puddle. I remembered the place and let the man get through with his work. When he had gone I went and examined the puddle. Its formerly clear waters had disappeared, and it resembled a pool of blood, filled with roe to such an extent that the water had a jelly-like consistency. Although the conditions in this case were not very favorable, as the puddle was too small for the enormous mass of roe, and as the man, utterly ignorant, of course, of his having acted as an artificial hatcher of fish, had, besides roe and milt, thrown in blood and different parts of the fish, I nevertheless determined to see whether some of the roe could possibly be hatched. I therefore put some of it in a glass vessel containing fresh sea-water. I soon had the satisfaction to see that nearly all the eggs floated toward the surface, a sure sign that they were not yet spoiled. After awhile I examined these eggs microscopically and became convinced that they were not only sound but that they had also become impregnated. The peculiar preliminary process termed "the separation of the yolk" commenced simultaneously in all the eggs, and during this and the following days I could witness all the different phases of development which I had formerly observed in eggs artificially impregnated by me. I have, therefore,

not the least doubt that most of the roe collected in the above-mentioned puddles when taken out by the tide would develop, and all this in spite of the circumstances being rather unfavorable in this case, especially as the fish from which this roe had come had been dead for quite awhile.

I have given a full account of these occasional observations made by me during the fishing-season, because I thought they might be of general interest. My chief object this winter was, however, to observe the phases in the life of the growing young codfish during their stay in their native place. As I had thus by this winter's observations only supplemented former investigations by extending them over a full year, and had as far as was possible under the circumstances thrown light on the first period in the natural history of the codfish, I will, before I close, give a brief review of the results and the probable conclusions which may be drawn from them regarding the place of sojourn and mode of life of the growing codfish.

During the first days after the young codfish have been hatched, they are the most helpless beings which can be imagined. The large umbilical bag keeps them always floating near the surface of the water, where they are tossed about by waves and wind without being able to offer any resistance. As soon as this bag has been absorbed, they begin to lead a more independent life, although they are not yet strong enough to resist the current. A natural instinct leads them deeper into the water, where they are not so much exposed to its influences. Their food during this period and later, as long as they lead a roaming (pelagian) life, consists of different small pelagian animals, especially the small, transparent crustaceans known as "herring-food," because they form the principal food of the herring during the summer. Toward the end of summer, when they have reached the length of about an inch, they begin to come near the shore and lead a more stationary sort of life. This change is effected gradually, and begins with their seeking the company of the medusæ, which about this time are by the current driven toward the shore in enormous numbers, and thus actually show them the way. Thus the fish become more accustomed to the shallow places near the shore, and to the food found in these places, but as yet they are by no means fully prepared to assume their stationary mode of life near the shore.

After having left the medusæ they for some time roam about near the coast, and are often found in large schools near the so-called "Strömblak," where the current has gathered near the surface of the sea a large number of floating objects, *e. g.*, live, dead, and half dead medusæ, pieces of algæ, &c., or they keep near the outer coast, where they are unmercifully persecuted by the voracious pollack and other fish of prey, as well as by sea-gulls and other birds. Love of life, however, makes them gradually leave these dangerous places and go to the more sheltered sounds and inlets, where they finally adopt the stationary mode of life near the coast, which the young pollack have adopted some time before them, and gradually accustom themselves to the food which here is found

in abundance, consisting of different littoral animals, especially crustaceans.

The young codfish may soon, however, be distinguished from the young pollack by their different habits. The young pollack are generally found near the surface, while the young codfish keep nearer the bottom, the deeper the larger they grow, and their favorite places seem to be those where the coast falls off abruptly.

It will be noticed that on the whole the similarity in the stationary mode of life between the young codfish and the young pollack is only a seeming one, but that the former are in reality migrating all the time, which circumstance only escaped my observation because they do it so gradually and at different times according to their different age. Those young fish which in the beginning come close to the shore migrate in proportion as they grow larger into deeper water, and their place is taken by smaller and younger fish which hitherto have kept near the medusæ, or have been in that state of transition when in large schools they roam about near the outer coast. These again, as they grow up, very gradually seek the deeper places, which have been left by the other young fish, which migrate to still deeper water, &c., until at last at the age of one year the young fish, well known to the fishermen by the name of "algæ-fish," make their appearance at a depth of 20 to 30 fathoms on the sandy bottoms between the groves of algæ near the outer coast.

I believe that, by my former remarks, I have proved satisfactorily that these fish are not different from the codfish proper, but that they are the young fish from the preceding year. It is true that on certain parts of our coast, especially in the deep fiords, small codfish are found, which always keep in shallow water and never grow as large as the large codfish; but this is only caused by the natural conditions being less favorable to the development of the codfish than near the outer coast. In the fish-market in Christiania I have seen codfish which only measured one foot in length, and which, nevertheless, had mature roe and milt. Such instances never occur near the Loffoden Islands, where the smallest codfish having completely developed sexual organs never measure less than a yard. Even in the largest algæ-codfish found near these islands I, in most cases, only discovered very insignificant beginnings of roe or milt, which show that all these fish occurring on the algæ bottoms are by no means fully grown, and are only temporarily sojourning there, and finally go out to sea, where probably in a short time they assume the distinct characteristic features of the codfish. As yet I cannot say from personal observations at what time of the year or at what age they leave the coast, but hope that future investigations will throw more light on this matter. I consider it very probable, however, that their "going out" is as gradual and scarcely noticeable as their previous migrations to a shorter distance from the coast.

From the fishermen I learned that the one-year-old codfish occur most numerously a short time after the close of the winter fisheries and far into the summer, for those persons who stay at home are in the habit

of catching them with small lines; but toward autumn their number decreases very perceptibly, although even then "algæ-fish" of different sizes are occasionally caught. From this it appears as if the "going out" took place, to some extent at least, in the course of the second year after the hatching. It is possible, however, that later in the year they only barely go out to the deep water, where there is no fishing at that time, and that they stay near the outer side of the great ridge (Egbakke). I consider it highly probable that some, although, comparatively speaking, a small number, remain somewhat longer, until they are fully grown and their roe and milt is fully developed, and these are probably the fish which are known to the fishermen under the name of "coming-in fish," "ridge-fish," and "bottom-fish," and which are by them considered as the fore-runners of the schools of codfish which come in at the beginning of winter. It is quite natural, however, that there is not room enough for all the masses of fish which gradually migrate from the algæ bottoms toward the deep. The greater number of them must, therefore, go farther in order to find sufficient food. Gradually, therefore, they reach the outermost bottoms, from which they again migrate farther.

The actual place of sojourn of the codfish is, as I said before, not known with absolute certainty. I shall, however, venture to make a supposition; all the more, as from several reasons I have felt constrained to abandon the supposition expressed in my first report, that they staid in the great deep between the ridge and the coast. Later investigations have made it seem probable that their place of sojourn is not the deep between the coast and the ridge, but this ridge itself. Early observations have shown that this ridge, which, though interrupted in several places, forms a continuous series of shallow places, extends along the greater part of our coast at a considerable distance from the land, and that it has always abounded in fish of various kinds, among the rest large codfish. People formerly believed that these codfish, distinguished from other codfish by the name "bank-fish," always lived here, and must consequently also spawn and develop here. But my observations on the propagation and development of the codfish have convinced me that this cannot be the case. According to these observations *all* the codfish, without exception, must spawn near the coast, in order that the eggs may be properly impregnated and hatched, and that the young fish may find the food which they need at the various stages of their development. Nothing therefore seems more natural than to suppose that the "bank-fish" and the codfish are one and the same fish, and that this ridge stretching out far at sea is the proper place of sojourn not only of the codfish, but possibly of other fish which, like them, only appear near the coast at certain seasons of the year, *e. g.*, the herring. In this locality, therefore, the full grown codfish live all during summer and autumn, and only when their sexual organs have been fully developed, which probably takes place the third year after the hatching, do they gather here in large schools in order to come nearer to the coast for the purpose of spawning.

V.—REPORT OF PRACTICAL AND SCIENTIFIC INVESTIGATIONS OF THE COD FISHERIES NEAR THE LOFFODEN ISLANDS, MADE DURING THE YEARS 1870–1873.

BY G. O. SARS.

A.—REPORT FOR 1870.*

It was my intention on this journey, if possible, to extend the observations of the development of the winter-codfish which I had made last year, and at the same time to renew my observations on certain points which I thought needed corroboration. By having made my observations at different seasons of the year, I had gradually succeeded in following the development of the winter-codfish from the egg to the age of one year; and among the rest I proved one important fact which will play a prominent part in all future investigations of the cod-fisheries, viz: That the small form of codfish, which, under different names (algæ fish, bottom-fish, &c.), is found on our northern and western coasts all the year round, is not, as was formerly thought, a separate variety of the codfish, but the offspring of the winter-codfish; therefore winter-codfish which have not yet reached their full development. I had, likewise, in the course of my investigations, convinced myself that the many differences of color and shape occurring in these fish are, if not exclusively, at any rate to a great extent, due to the surroundings in which they live, especially the nature of the bottom, and the food which is dependent on this; and that if these surroundings are changed, the fish assume a different appearance in an astonishingly short time. It was my object this year to examine these fish during their further growth, and, if possible, to study and explain the various phases in their mode of living, as I had formerly done with regard to those young fish which had not yet reached the age of one year. I found, however, very soon, that the older the fish grew the more difficult such an investigation would be. Formerly I had been able to make my observations with the greatest ease from my boat, or even from the shore; and changes in the weather had never seriously interrupted my work. All was different now. The fish had long since left the coast, and gone out to the vast ocean; and I was thus obliged to use my fishing implements in order to get any idea at all regarding their place of sojourn and their

* Indberetning | til | Departmentet for det Indre | fra Cand. G. O. Sars om de af ham i Aarene 1870–'73 anstillede Praktisk–videnskabelige | Undersögelser angaaende Torskefiskeriet i Lofoten. | Christiania, 1874. Translated by Herman Jacobson.

mode of life. In the following, I intend to give all the facts I ascertained in this manner; and, as in my former reports, I shall first give a simple description of the course and the method I pursued in my investigations, and then give a brief *résumé* of the results.

On the 9th of May I left Christiania by steamer, and, traveling *via* Bergen and Trondhjem, I arrived at Svalvær on the Loffoden Islands on the 20th. From Svalvær, I immediately went to the fishing-station of Skraaven, which, in many respects, I had found the most convenient place for my investigations; and where, moreover, I had last year left a quantity of apparatus. The season was certainly farther advanced than when I left the Loffoden the last time; but I was pretty sure that I would not lose my thread this time, but could easily connect my investigations with those of last year.

My last method of fishing, which in the course of my investigations I had had to change quite frequently, had consisted in using short lines, with which last year I had caught a considerable number of fish, and I therefore intended to make use of them again; at any rate, in the beginning. There was one difficulty, however, connected with this, viz: the scarcity of bait. Formerly I had been fortunate enough to obtain fresh herring; but now I could not get a single herring; neither could I expect to obtain any shell-fish, as during the winter fisheries nearly all those near the fishing-stations had been used. The only bait which I hoped to obtain was a worm, the Fjæramak (*Arenicola piscatorum*), which are found here in large numbers, and which are successfully used as bait for small fish at different points along our coast. This worm, which lives deep in the sand of the shore, can only be obtained by being dug up with a spade; an operation requiring time and considerable skill, if it is not to be cut in pieces.

After I had spent several hours in procuring such worms I had my lines prepared, and set them in those places among the outer islands where the water has a depth of 20–30 fathoms, and where last year I had caught many fish. I was again successful; but what struck me as peculiar was the circumstance that nearly all the fish which I caught were so large that I could not well consider them as one-year-old fish, but rather as two-year-old fish; and as I must get the one-year-old fish, I could not be satisfied, but had to find out where these fish staid. By setting my lines nearer to the coast, and in shallower places, I succeeded in catching some one-year-old fish; but so few, that I became convinced that the great mass of these fish did not stay here. There was, therefore, no other chance left but to make investigations at random, with the hope of finding their place of sojourn. I had been obliged to do similar things so often during my previous investigations, that I was by no means worried by it; as I had not the slightest doubt that sooner or later I would find the one-year-old fish.

Instead of the heavy line I got myself a thinner hand-line with which I intended to fish at various points, and which would enable me to go

over a larger space of the bottom in a day than I could otherwise have done in a week. I was not particularly successful near the shore, but the pulling at the line by fish biting the bait was quite lively when I approached the hidden depths lying farther out toward the places where the bottom falls off abruptly toward the great deep. During winter when the weather is stormy these places are almost inaccessible, and then present one mass of seething foam. They are well known to the fishermen as good summer fishing-places, and are visited by them especially during the time when the pollack approach the shore. The pollack-fisheries are almost exclusively carried on in these places. At this time, however, the pollack had not yet arrived, and such localities were therefore exclusively held by their relatives, the cod.

The majority of the cod which I caught here (and I caught no other fish) were certainly one-year-old fish, having an average length of one foot; but occasionally I also caught larger fish which required considerable exertion in hauling up, and whose age was certainly three years at the very least. Of two-year-old cod I found but few. Most of the cod caught here were of the variety generally termed "algæ fish," as their color was more or less a reddish brown with a beautiful golden gloss on the sides, and their shape somewhat stouter than is generally the case. I knew, however, that this was only owing to their living among the red algæ; and during the course of my observation this opinion was fully confirmed.

During the following days I continued my observations in the many deep places which are near this fishing-station, and with the same result. There was no difficulty in obtaining as many one-year-old fish as I desired. These excursions were not without danger, and would have been still more so if I had not had experienced people with me. As soon as the heavy waves begin to come in from the sea, which cannot always be distinctly seen from a small boat, these places are not to be trusted. The weather may be perfectly calm, and the sea around these places be as smooth as a mirror, and still there is danger, unless great care is taken, of being suddenly ingulfed in the waves without the least chance of escape. It is, therefore, not advisable to go with the boat on these deep places, but rather to keep near the edge. It is astonishing to observe how the sea near to the boat suddenly rises in the shape of a broad pyramid, which slowly sinks down to the general surface. For a long time again the sea may look perfectly smooth, but as soon as the fishermen have noticed the above-described suspicious movement of the sea they cannot be induced to approach the place, for if the boat should be where the pyramid of water rises, it would surely be dashed to pieces. These dangerous places have caused many losses during the winter-fisheries, when boat-crews which were not well acquainted with these waters got within their reach. But by keeping at a certain distance one may, without any special danger, witness the grand and interesting sight of the great waves rising and falling. It may happen, however,

that one has to wait a long time before anything is to be seen. Every now and then the water is rising a little over the deep places but without disturbing the general calm, but suddenly the broad pyramid of water assumes larger proportions. At its top it has the appearance as if a fine smoke was rising from it, and at the same time it makes a sort of advancing movement, just as if some monster of the deep were pushing its snout out of the water; this is followed by a low rushing sound, as of a passing storm, and presently the sea rises to an enormous height, like a broad green and shining rampart, fringed at the top with seething foam, which falls forward with a terrible fury, beating everything around into a mass of whitish froth. While lost in admiration of this grand phenomenon one feels the boat suddenly raised up high and just as quickly flung down deep, and fear fills the heart that all is lost; but this feeling, which naturally overcomes a person who witnesses such scenes for the first time, soon passes away. In a short time everything is as calm as if nothing had happened, the large waves which have been occasioned by the breaking of the watery pyramid recede, and soon their distant roar as they break against the coast shows that the catastrophe is over. After the fury of the element is spent there generally follows a longer period of calm, as if the ocean were gathering new strength for another eruption, which is sure to take place sooner or later.

I have not given this description for my own or for the reader's amusement, but because (as will be seen from the following) this natural phenomenon had a good deal to do with my investigation of the fisheries. For the question arises why the fish show a decided tendency to keep near these deep places; and the most plausible explanation is found in the peculiar conditions produced by the heavy waves going over these places. The bottom is always rocky and has a peculiarly rich vegetation of algæ; the large algæ (*laminariæ*) flourish here as in all places which are exposed to the immediate influence of the waves. On and among these algæ there live a large number of lower marine animals from a size scarcely visible to the naked eye to those of considerable dimensions. Especially do the crustaceans live here which form the favorite food of the cod, as well as crabs, &c. It is not so easy, however, for the fish to catch these small animals, their instinct having taught them to avoid their greedy enemies by hiding among the algæ and by darting away with lightning-like rapidity. The cod would therefore not catch any more here than in other places where there is a similar algæ vegetation, if it were not that the above-mentioned violent agitation of the water afforded aid from time to time. As soon as the sea after a period of calm begins to rage in these deep places, a general confusion is, of course, produced among the small animals; they are whirled about and cast in every direction. This is the favorable moment for the cod, and as soon as the watery pyramid has broken, they come in large numbers from all parts and feast on the little marine animals which are momentarily powerless and stunned by the sudden

shock. The same is repeated every time the waves break, as during the interval of calm the marine animals will again gather among the algæ.

I thought that now I had found a place where all during summer I would be sure to find the necessary material for my investigations regarding the further changes of shape and color which the cod undergoes during its development. In this, however, I was mistaken. Toward the end of June the number of fish in these places decreased in a remarkable manner; and I likewise observed that I could never get a fish to bite the usual bait (*Arenicola piscatorum*), even when I dropped my line in places where I knew there must be small cod. Only every now and then I caught a few, and, strange to say, most of these in places where there was sandy bottom, while the algæ-bottoms seemed deserted by the fish. Most of the fish I caught also presented a different appearance. I very rarely caught any reddish-brown so-called "algæ-fish," with their peculiar golden gloss; and most of the fish I caught were of a pale greenish color and had a silvery gloss.

I soon found the cause of this change of the cod's place of sojourn and the consequent change of color. Several times when in calm weather my fishermen had rowed me along the sounds between the numerous little islands, distinguished by their shining white sandy bottom, there was frequently the appearance as of a dark cloud passing over the light bottom, which quickly disappeared when the oars were put in motion. I soon convinced myself that this phenomenon was occasioned by dense schools of small silvery-white fish, which appeared in large numbers in the shallow places near the shore. This little fish is well known under the name of sand-eel (*Ammodytes lancea*), and is considered an excellent bait for the pollack. But by examining the contents of the stomach of some cod, I found that the latter does not disdain it either, for it contained scarcely anything else but such fish. I also found the natural explanation of the above-mentioned changes in the one-year-old cod and of their fastidious taste. All the cod, both young and old, had left their former hunting-grounds and had gathered for the pursuit of the dense schools of sand-eels which were approaching the shore. On a beautiful calm day (the 28th of June) I was fortunate enough to observe this. While my fishermen were rowing me across one of those 6–10 fathom-deep inlets leading to the usual sand-eel places, I could see distinctly against the light sandy bottom enormous schools of large fish, all turning their heads in the same direction, viz, toward the shore. I immediately got out my line, thinking I would make a big haul in places where no fisher had ever dreamed of looking for large cod. But I was disappointed. The slow manner in which these fish moved showed that they were not very hungry, but had already taken a good breakfast. Although I put the daintiest pieces of shining sand-eel on my hook, I could not get a single fish to bite. As soon as the hook got near the fish they came swarming toward it from all sides, but

after having thoroughly examined and smelt the bait, they coolly turned their backs to it. By moving the line and causing the shining bait to dance about in the water, they could be made to repeat this maneuver, but none of them would bite. Only a fine line which I had brought from Christiania, and to which a pretty little fish of German silver was fastened, which certainly did not resemble any fish known to the cod, but whose shining gloss, similar to that of the sand-eel, seemed to have some attraction, and by drawing it slowly up through the water I succeeded in attracting a large cod nearly to the surface. It was evident that it had a great desire to swallow the little fish, but, on the other hand, it seemed to have an idea that everything was not all right, and therefore it refrained from satisfying its desire. Only when the bait was a few feet from the surface and threatened to leave the water altogether, the cod took courage and with a quick jerk snapped at it, but, as if frightened by its own boldness, it just as quickly shot away again and joined its comrades. In this, however, it would not have been successful if my hook had been stronger; but it was not calculated for such large fish; the cod consequently escaped with the fright and a slight scratch of the mouth. When I hauled in my line the hook was bent perfectly straight, and the metallic bait had been scratched in several places by the sharp teeth of the cod. This little description may serve to show some of the characteristics of the cod, which certainly is not so stupid as is generally made out, but whose greediness often runs away with its reasoning powers.

I knew now that the only bait with which for the time being I could hope to catch cod would be its own food at this period, viz, sand-eels. This little fish, which is but little esteemed farther south, plays quite an important part in these regions, as it occurs in enormous numbers. Since it exercises no little influence on the movements of the cod, I shall report what I learned regarding its occurrence and mode of life. During winter it seems to live at a great depth, for it is never found near the shore, and only occasionally in the stomachs of fish caught in deep waters. Toward the beginning of summer they commence to make their appearance by coming in large and dense schools to the sandy bays and sounds near the fishing-stations. In spite of its small size (it measures scarcely a span in length), it is a very greedy fish and devours various small pelagian animals, which are often heaped together by the current in the sandy bays in enormous numbers, and these bays are the favorite resort of these fish and their spawning-place during summer. The comparatively large grains of roe, having a beautiful reddish-yellow color, do not float about like the roe of the cod, but are laid on the loose sand on the bottom, where they go through their development. This fish has the peculiar custom of digging in the sand, so that when the tide is out it may be taken with spades from the dry sand at quite a distance from the water, and this is really the only way in which the fishermen, at any-rate near this fishing-station, procure this bait. It cannot be caught

with common nets, for it is so small and nimble that it can slip through the smallest opening. Even if the net was so fine that they could not get through, it would nevertheless, if applied in the usual manner, be of no avail, as every individual fish would have managed to escape before reaching land, and would have dug itself deep down among the loose sand. In some places, however, these fish are caught in enormous numbers with the so-called sand-eel net, an implement which can only be used for catching these fish. It consists of a large square piece of closely-woven stuff, which has to be manipulated by several boat-crews. During the spawning season of the sand-eel, this net is sometimes, with considerable trouble, got under the schools; by a quick movement the four corners are then raised, and the contents emptied into large boats. The fish are then taken to the shore, and without any special preparation they are simply piled up in great heaps, from which they are gradually taken in the course of the summer and autumn, just as occasion demands, and used as food for men and cattle.

This fish possesses the remarkable peculiarity that, piled up in this manner, it will keep for a long time without entirely decomposing, and although it is not probable that this half-putrefied food is very wholesome if partaken of for any length of time, it is nevertheless eaten a great deal in many districts and actually considered a delicacy.

The cod and the pollack are, however, more fastidious in their taste, and there is absolutely no use in offering them anything but quite fresh sand-eel. As soon as it is a day old it becomes unsuitable for bait. Whenever the sand-eel only is used for bait the above mentioned net is not used, but whenever bait is needed, they are dug from the sand with spades. They cannot, however, be caught in this way at all times. In clear, sunny weather the sand-eel does not like to go on the sand. One may therefore often hunt for it in vain for a whole day, while the following day hundreds may be caught. Nor can one count on catching it in this manner in every place. The so-called sand-eel places known from time immemorial are but few in number, and are often limited to a very small space. Near the fishing-station of Skraaven there is only one such spot, covering scarcely more than 40–50 square yards. It consists of a reef covered with loose sand, stretching across a narrow sound. When the tide is high this reef is completely hidden by the water, while at low tide the sound may be crossed at this place without any danger of wetting one's feet. From this very limited place all the fishermen of this station get their bait, and it is sometimes crowded with people, each one digging in the sand. It is a comical sight to see this crowd of fishermen engaged in this manner, and to observe with what rapidity and precision they perform their difficult task. As soon as by removing a quantity of sand some of the small, shining fish have been brought to light, one must either by a quick movement of the spade throw them up higher on the dry sand or kill them. If not, they will immediately dig further down into the moist sand, and if one were

to attempt to catch the live fish with the hands they would, like eels, slip between the fingers. I have more than once witnessed this peculiar fishing process, as I had to get all my bait in exactly this manner.

Since I had learned to know the taste and place of sojourn of the cod at this period, I no longer looked for it in those places where it had formerly been found in such large numbers, but I cast my lines where I supposed any sand-eels to be, viz, along the edges of the deep ravines rising from the depth of the ocean toward the sandy bays. My fishing in these places was successful beyond all expectation, and I returned nearly every time with my boat heavy laden with fish. I not only caught one-year-old cod in this manner, although the greater number were certainly such, but also two and three year old fish; occasionally I even caught unusually large fish of exactly the same size as the common winter-cod. Nearly all, both the one-year-old and the older fish had a very light grayish-green color with a silvery gloss on the sides and the usual dark spots; they possessed in other words all the characteristics of the so-called "sand-eel cod," well known in the Loffoden. One of the largest fish, measuring 1½ (Norwegian) yards in length, I took home to examine more closely and had its picture taken and colored exactly, in order to compare it with the winter fish which was well known to me. It was then seen that even down to the most minute details it was the exact image of the common winter-cod or skrei, and neither I nor the fishermen to whom I showed it could point out a single difference in either shape, color, or size. The only thing which distinguished these large sand-eel cod from the winter-fish was, that the generative organs were not yet fully developed, although in the larger ones both the roe and the milt could be plainly discerned, and so far developed that they certainly during the coming winter would have come to the fishing stations as real skrei with fully matured roe and milt.

While I continued my investigation of the mode of life and place of sojourn of the so-called sand-eel cod, the pollack began to make its appearance. All the fishermen were now busy getting ready for pollack-fishing, and left the cod entirely undisturbed for the present. The food of the pollack at this time consisted likewise for the greater part of sand-eels. This could be seen by opening the stomach of some that had been caught, but likewise by direct observation. When my fishermen rowed me about among the outer islands I often noticed on the rocky ledges turning toward the Westfiord an unusually large number of birds (gulls) collected in a small space. There was nothing specially striking in this; but the way in which these birds acted was peculiar in the highest degree. With their snow-white plumage forming a very striking contrast with the dark background of the rock, they sat frequently in regular rows like soldiers, all turning their heads in one and the same direction. Not a movement could be noticed, not a sound was to be heard; they looked as if they had become petrified and had firmly grown to the rock.

Suddenly they became animated; as on a given signal the whole flock raise their long wings at exactly the same moment; with deafening screams they rise and wing their flight over the sea; like a thick white cloud they may be seen to descend at some distant point of the ocean which resembles a foaming whirlpool. This is occasioned by the pollack which have surrounded a school of sand-eels and forced them toward the surface of the water where they can easily catch them. The poor little fish are at the same time attacked by the birds from above. This lasts but a short time; soon the school of sand-eels is scattered in all directions, the pollack have gone into deeper waters to renew the chase, while the birds, nearly every one with a glittering sand-eel in its beak, are slowly flying toward the rocks which they left a short time ago, to watch their chance for catching more fish. The fishermen also watch this opportunity when the pollack are near the surface, and, if they are in time, generally catch a few. But what interested me specially was the fact that quite frequently large and small cod were caught instead of the pollack. This happened oftenest in the beginning of the pollack-fisheries, showing that the cod, which generally keeps near the bottom, occasionally imitates its more lively half-brother's mode of life.

For a time the fishermen's pollack-fishing and my cod-fishing were quite successful. But suddenly a change took place. The fishermen came home discouraged with almost empty boats; the pollack and the birds had been there as always, but none of the fish would bite. My cod-fishing was not so successful either, and half a day often passed without a single bite. I soon found the cause of this. Both the pollack and the cod now used another kind of food, which they seemed to prefer to the sand-eel. Some days previous the many pillars of smoke-like spray seen on the western horizon indicated that a considerable number of whales were approaching the Westfiord; and on a fine, calm day, when I was out in my boat, about the middle of the Westfiord, I was suddenly surrounded on all sides by blowing and snorting monsters of the sea. Gigantic whales showed their broad, black backs over the surface, often in dangerous proximity to my boat, and with a hollow noise squirted the watery spray high up into the air, while nimble dolphins leaped high above the water, their sides glittering in the rays of the sun. Occasionally a sudden foaming motion could be noticed in the water; just as if the waves were breaking against some hidden rock, two high pointed fins rose above the surface and quickly disappeared again. This was the gigantic fish well known in these latitudes by the collective name of stórje, while farther south it is with greater accuracy called "makrel-stórje," and which belongs to the same species as the tunny, so highly prized in the Mediterranean. By looking down into the clear water I could often see large and small schools of scared little fish swim underneath my boat with lightning-like rapidity, and when hard pressed by their pursuing enemies, leap high over the surface, showing their shining silvery sides. Although I did not succeed

in catching any of them, I had not the least doubt that these were young herring, and that they formed the food not only of the above-mentioned large marine animals, but also of the pollack and the cod, and that this was the reason why they would no longer take the bait offered to them.

By examining the stomachs of some of the fish caught at this time (both pollack and cod), I found them crammed full, no longer with sand-eels, but with young herring. The herring is a more uncertain fish than the sand-eel, and it was purely accidental if any of them approached the coast. The great mass of them generally kept far out on the Westfiord, and I have reason to suppose that both the pollack and the cod followed them; and that the entire failure of the pollack-fisheries at this period, as well as the unusual scarcity of other fish near the coast, could be ascribed to this cause.

Before I left the Loffoden I wished to make observations in some other localities, and for several reasons I selected the two stations of Risvær and Brettesnæs, lying east of Skraaven. I staid longest at the first-mentioned place, which I had not yet visited, because it seemed to afford special interest in my investigations. It is one of those fishing-stations east of the Raft Sound, which have long since been deserted, but which were much frequented in olden times. About 30–40 years ago rich winter-fisheries were carried on here every year. At present only one family lives here, but traces may still be seen of the many fishers' huts which served as places of shelter to the numerous fishermen who came here. The place must have offered many special advantages for fishing. The fishermen had not to go out very far; and from the windows of the houses they could distinctly be seen hauling in their nets. Numerous outer islands afforded ample protection against the sea, more so than in most other fishing-stations. It might seem premature to give any definite opinion as to the cause of the decline of the fisheries. I shall, however, at the end of my report refer to it, and give my view of the matter, as well as some facts which might be of weight. For the present I shall simply report the course of my observations in this place.

My first object was of course to ascertain whether the young of the winter-cod were found here in as large numbers and under the same conditions as in those places where the winter-fisheries proper are carried on. By conversing with the people of the place I got all the information I desired. The young of the winter-cod is well known here. It is found all through summer in large numbers, and this very year the fishing for this fish had been quite successful. The fish that were caught measured, on an average, one foot in length, and were, therefore, one-year-old fish. They were caught so readily that even two men going out with their lines would in a comparatively short time have their boat quite full. During the first days of my sojourn I likewise caught many fish, both on the algæ bottoms and everywhere among the islands. As

long as one had bait (for which sand-eels were used) there was no difficulty in procuring in a very short time a tempting dish of delicious small fish. Regarding the looks of the fish, it had as at Skraaven sometimes the characteristics of the algæ cod and sometimes those of the sand-eel cod, which latter gradually became more common, as the coming in of the sand-eels took place at this time.

One day I devoted to fishing at a great depth (about 100 fathoms). The bottom was everywhere composed of clay, occasionally mixed with gravel and small pebbles, and the fish which I caught here were, as a general rule, larger than those caught in shallow water. While in shallow water one might always be sure that any fish that bit would be cod (just as the fly-fisher on our small streams is sure that any fish which snaps at the fly is trout, *Trutta fario*) very different kinds of fish were caught here, which could already be noticed by the way in which the fish bit. Sometimes the line suddenly felt heavy without any previous jerk at it having been noticed, and, after a troublesome hauling, a large slimy brosme or cusk (*Brosmius vulgaris*) came up, its eyes sticking far out of its head on account of the diminished pressure of the water. Another time there were some gentle, scarcely perceptible, pulls at the line; but in beginning to haul it in one could notice that no small fish was coming. The higher the line came the lighter it got, so that toward the end it felt as if both fish and hook had been lost, and before it had been hauled in entirely a beautiful pink-colored ner (red fish) or Norway haddock (*Sebastes norwegicus*), with eyes protruding and mouth wide open, leaped out of the water, the hook firmly fixed in its mouth. Again, there would be a powerful pull at the line, so that for a time one could scarcely move it, and presently it would get so light as to induce the belief that the fish had been lost; then again it began to feel heavy; this time it would be a halibut (*Hippoglossus maximus*) which had thus to suffer for its greediness, and which had to be hauled in very carefully and knocked a few times on the head before it could be taken into the boat. Often a large cod would bite, and, corresponding to the nature of the bottom, it would have a very pale grayish-green color. Some very large but very lean cod which were caught here, covered all over with parasites (fish-lice), were, by my fishermen, called winter-cod which had been left over from the last winter fisheries, and which, from some reason or other, had not found their way to the great deep where the great mass of the winter-cod always goes after they have done spawning. Such specters are every now and then caught all the year round, and their miserable starved appearance is in a very plausible manner explained by the fishermen, who say that they do not find sufficient food to which they had been accustomed while farther out at sea.

For some time yet I was quite successful in my fishing, but soon there was a change, and the same complaints were heard from the fishermen, that fish were scarce. The numerous pillars of smoke-like spray which, on certain days, could be seen far up the Westfiord, resembling the chim-

ney-smoke of a large manufacturing city, indicated that dense schools of young herring had now also reached east, and that not only the whales but also the cod were feeding on them. The same I found to be the case at Brettesnæs, where I staid a few days. At Skraaven the cod had not yet come near the shore, although it had begun to make its appearance at the usual fishing-places, the algæ bottoms.

At the same time that I made these investigations of the one and two-year old cod I had also occasionally devoted my attention to the tender young ones from last winter, but had found that this summer was particularly unfavorable to these investigations. On account of the unusually calm and steady weather, which lasted all summer, with scarcely an interruption, the current, as is usual in such weather, was generally going out of the Westfiord and carried everything which could not resist its power out to the ocean. The water near the fishing-stations where I staid was, therefore, generally quite clear and transparent without ever showing that rich life of different pelagian animals which on a former visit I had noticed in these parts, and which certainly was closely connected with the occurrence of the young cod. I had in the beginning of my stay at Skraaven occasionally noticed, especially after a short storm from the southwest, that these diminutive fish, measuring scarcely a few lines in length, were playing about near the surface of the water in the same places where I had observed them on former occasions; but never again did I see such enormous numbers as in 1866. I often found that what I had taken for the young of the cod were the young of other fish. A young fish distinguished by a considerably shorter and plumper shape than the young of the cod appeared on certain days in very large numbers in the places which had formerly been frequented by the young cod. On other days the sea would be so void of all life that one could row long distances without even seeing a medusa.

The period in the development of the young cod which this year I desired to investigate was the transition from the roving life near the surface of the water to the more stationary mode of life near the shore; in other words, their change from pelagian to littoral animals. The above-mentioned natural causes unfortunately prevented me from making any exhaustive observations. I several times observed the peculiar transition period when the young cod go under the medusæ. But these, as well as later observations, were by far too isolated to get any reliable corroborations of facts which I had ascertained by former observations. Even toward the end of my stay, when the young cod had begun to show themselves near the shore, their number was so small that I had no hope of getting at any new facts. The only additional fact was this, that their passage to the deep begins much earlier than I had formerly thought. In order to ascertain this I had a sort of fish-trap constructed, which I set in different places, varying in depth, and baited it with refuse of fish. In this trap I caught, as early as the beginning of

August, at a depth of 20–30 fathoms, unusually large young cod, which certainly belonged to this and not to the preceding year, and which, therefore, must have come near the shore very early.

My experiments with the fish-trap were, however, interrupted in a very unexpected and peculiar manner by a marine animal which is well known in these latitudes, and much abhorred by the fishermen on account of the injuries it inflicts on the fisheries. This is the so-called hag-fish (*Myxine glutinosa*), a very low form of fish, with a soft, boneless, slimy body, without eyes, and even without a clearly-developed head, resembling a worm rather than a fish. During the winter-fisheries the fishermen, to their disgust, are often made aware of the existence of this animal, especially on soft, clayey bottom. When, as often happens, the fishing implements have to remain in the water for several days on account of storms, the majority of the fish caught on the hooks or in the nets are often entirely destroyed by the hag-fish, which penetrates the skin of the fish and in an incredibly short time devours all the soft parts, leaving nothing but skin and bones. I had no idea, however, of the enormous abundance in which this hurtful animal occurs. Wherever I set my trap in deep water, either on hard or soft bottom, they always found their way to it, attracted by the bait, and destroyed everything in the trap by the incredible quantity of slime which this animal secretes, and with which it covers everything it comes in contact with. Once, when I had left my trap for a day on soft, clayey bottom, at a depth of about one hundred fathoms, I found it completely filled with thousands of these disgusting creatures, which had changed the contents of the trap to a compact mass of tough slime which could only be removed with the greatest trouble, and which made my trap useless for quite a number of days.

Toward the end of August I left the Loffoden for the south. But as I wished before my return to examine a point which lay beyond the limits of the fish district proper, I went to the island of Bodö, where I intended to stay for a while, in order to ascertain whether the young of the winter-cod were found here under the same conditions as on the Loffoden. The time selected by me was unfortunately not a favorable one, as large schools of young herring had just made their appearance, so that the fish were enticed away from their usual places of sojourn and together with pollacks, whales, and other marine animals were chasing the delicate little herring. Although I was therefore not very successful in my fishing, and could not by direct observation get a complete idea regarding the occurrence and mode of life of the cod in these regions, I nevertheless, from fishermen and other people well acquainted with the fisheries, obtained some very interesting information, which, in the following, I shall briefly report, reserving for the end of my report the conclusions which may be drawn from it.

At the same time that the Loffoden fisheries are going on, it may happen here (at Bodö), especially during south or west winds, that the whole

sea right up to the harbor of Bodö is thick with floating roe. There can be no doubt that this is the roe of the cod; but the question is, where does this enormous mass of roe come from? The general opinion seems to be that it comes from the Loffoden, and is consequently brought here by the current from the northwest. But, in the first place, it must be borne in mind that the distance from Bodö to the nearest fishing-station in the Loffoden is quite considerable, and secondly, that during the above-mentioned winds the current will always be in such a direction that it could not possibly bring anything from the Loffoden. During south and west winds the current generally goes from southwest to north-east, or follows the coast in a northerly direction, coming in through the different sounds between the outer islands. The roe can therefore not come from the Loffoden, but must simply have come in from the sea outside of the outer islands, where, consequently, large schools of winter-cod must spawn every year. I also heard that during the preceding summer enormous masses of cod "*mort*"* ($\frac{1}{4}$–$\frac{1}{2}$ year old cod) had been observed here all along the shore, even close to the harbor of Bodö. This has probably not only been the case that year, but is undoubtedly the general rule here, as well as in Loffoden. Only as long as no scientific observations had been made or published, people did not make any distinction between the young of the cod and the young of the pollack, and comprehended all the young fish found along the shore under the collective name "*mort*," meaning by this, principally, the young of the pollack. Even this year, which had been unfavorable to the coming in of the young cod, I had often occasion to observe them among the young pollack, measuring about a finger in length, and often occurring in considerable numbers. As far as the one-year-old or rather the 1½-year-old young of the winter-cod are concerned, they are found here all summer through in large numbers, together with the large cod, and under exactly the same conditions as in the Loffoden. I have no doubt that the same may be observed on many other points of the coast, and I have likewise obtained some corroborative information regarding this matter from several men who are intimately acquainted with the fisheries.

This is, in short, the result of many observations at Bodö. As I herewith closed my observations for this year, and as I have in the above already given a simple report of my investigations, I can add nothing but a brief *résumé* of the more important results gained by this year's observations, and the conclusions which may be drawn from them regarding the occurrence, mode of life, &c., of the winter-cod.

Among the more important results I must, as I have already said above, count the certain proof that the so-called "*smaagjed*"† is nothing

* "*Mort*" or "*mórt*," a purely provincial term, signifying cod or pollack, younger than one year.—TRANSLATOR'S NOTE.

† "*Smaagjed*" means "small pike," and is a provincial term applied to young cod of a certain age; no one, of course, supposing that they are real pike.—TRANSLATOR'S NOTE.

else but the offspring of the winter-cod. The name "*smaagjed*" is only applied to such cod which have attained to such a size that they can be caught with a line, which can scarcely be done before they are a year old. Younger "*smaagjed*" were, therefore, formerly not known here, as, strange to say, the enormous number of fish in younger stages found all along the coast had been entirely overlooked, and always mentioned together with the young of the pollack, under the collective name of "*mort.*" Just as during the preceding year it has been the chief aim of my observations to find the connecting link between these so-called "*smaagjed*" and the tender young ones of the winter-cod, I considered it my chief object to follow up this link by continued observations, and, if possible, to ascertain the connection with its final development—the full-grown winter-cod. Although the outlines of the circle representing the life of the cod have by no means been as yet drawn equally clear at all points, I believe, nevertheless, that so many and essential portions of it are so distinct that the remaining portions can easily be supplied. The connection of the so-called "*smaagjed*" with the larger "bottom-fish" or "algæ-fish," as a younger representative of the same fish, is quite evident; and as the connecting link between the latter and the winter-fish or skrei we have the so-called siil-torsk or sand-eel cod, which, in all essentials, shows the most complete agreement with the genuine winter-cod, from which it is only distinguished by not having its generative organs fully developed.

As far as the so-called "*smaagjed*" or the 1–2 year-old offspring of the winter-cod is concerned, it shows in its mode of life a series of phases or periods which are mainly dependent on mere outward circumstances, especially the different food which is thrown in its way; but as the occurrence of this food is by no means accidental, but with very slight variations of time and place is repeated in exactly the same manner every year, these periods in the mode of life of the "*smaagjed*" must be considered just as invariable as the former periods of the fish before it has reached the age of one year. We find, on the whole, that the cod is a very stationary fish, and that from the very beginning, when it appears near the coast, measuring about a finger in length and called "skrei-mort," it is constantly wandering from shallow to deeper waters. If other circumstances did not occur, this wandering would be continued without interruption; so that the cod, the older it got, would get farther and farther out into the deep. With a large number of the cod this regular development goes on undisturbedly, so that already in the second year a great many of the offspring of the winter-cod have reached the deep, or rather the edge of the great ridge rising from the deep, which they follow until they reach the ocean. Others of the offspring of the winter-cod which, during their wanderings, have got to one of the many algæ-bottoms, take so much delight in the food they find here that they stay on these bottoms for shorter or longer periods, and are soon followed by some of the "*smaagjed*" on their gradual journey from

the coast to the deep. Experience teaches them now to prefer the many hidden raised bottoms where the heavy waves break; and some of them assume here a completely stationary mode of life, which soon shows itself in their shape and color. The large and fat algæ-fish, with a very distinct reddish color and an unusually short and compressed shape, are such stationary fish. But even these may, in a comparatively short time, assume a different appearance, viz, when the coming in of the sand-eels entices them away from their old hunting-grounds. But the schools of sand-eels do not only entice away the cod living on the algæ-bottoms, but likewise a large number of those cod which have already reached the ridge (the "*eg-bakke*"), and these fish, which often are the exact counterparts of the winter-cod, may, on their return to the deep, remain on the algæ-bottoms and become genuine algæ-fish.

A new interruption in the normal development is occasioned by the appearance of the schools of small herrings. Following the old rule that everything new possesses a peculiar charm, the cod now prefer the herring to the sand-eel, although one should think that both would taste very much alike. Where (as it sometimes happens) the schools of herring come close to the shore, the same cod may have made the trip from the shore to the deep, and again from the deep to the shore, two to three times. As a general rule, however, the schools of herring keep farther out, and rather entice the fish away *from* the shore than *toward* it. These schools of herring consist either of large, fat summer-herring or of very small, young herring, probably that year's young ones of the so-called ocean-herring; and these are the ones which are specially enticing to the young cod. The same schools of young herrings also show themselves at other times of the year in different stages of development. For a long number of years small and large schools of half-grown (one-year-old) herring have during the winter Loffoden fisheries steadily made their appearance in the Westfiord, and stragglers have every now and then come near the shore, where they are eagerly caught and used as bait for the cod fisheries. I consider it extremely probable that both this half-grown herring and the very small herring roaming about the Westfiord during summer are the offspring of the ocean-herring.

I desire to draw special attention to this circumstance, as it is my opinion that the occurrence of these schools of small herrings in the Westfiord exercises a decided influence on the cod-fisheries. In olden times neither the ocean herring nor the schools of small herrings which come to the Westfiord regularly every winter were known in these latitudes. The ocean-herring seems to have kept further north, near the coast of Finmarken, where it took the place of the capelin (*Mallotus arcticus*) found there now. We have seen what a disturbing influence the schools of young herring, roaming about during summer, exercise on the normal migrations of the young cod, and the supposition lies very near, that the schools of larger herring entering the Westfiord in winter likewise influence the coming in of the winter-cod. As these schools of

herrings, just like those coming in summer, generally keep inside, *i. e.*, on that side of the ridge (egbakke) looking toward the Westfiord, and as this ridge all through the West-Loffoden is at a considerable (2–3 Norwegian miles) distance from the coast, they would here have but little or no influence on the coming-in of the cod, while in the East Loffoden this would be entirely different, because there the ridge is very near the coast. Especially south of the fishing-station of Skraaven does the ridge come close up to the shore, and this station, which in connection with the Molla Islands forms a long wedge stretching out into the Westfiord, likewise forms the natural boundary between the two great divisions of the Westfiord—the outer and the inner basin.

In the outer basin the fisheries have been successful at all times, only with this difference, that the fish have not always in the same number entered the limited sheet of water between Skraaven and Vaagen, called "Hóla." But in the division lying east of Skraaven, or the inner basin of the Westfiord, the fisheries have been exceedingly irregular. In olden times rich cod-fisheries were regularly carried on every year at the now deserted fishing-stations of Risvær, Swellingerne, Kanstadfiord, &c., but during the last few years only scattered schools have been observed at the fishing-stations immediately east of Skraaven, the Guldbrands Islands, Brettesnæs, and the Raft Sound, while the fishing-stations farther east, formerly so rich in fish, are now entirely deserted. I think the main cause of this is the schools of herring entering the Westfiord during the winter-fisheries. The chief mass of those fish which in former times made their appearance at the above-mentioned eastern fishery-station had then, as now, by following the ridge, been obliged to go round the south side of Skraaven in order to enter the inner basin of the fiord; and as in those times neither herring nor any other food was to be found here, these schools had, according to their custom, gone further, always following the ridge rising toward the coast.

Circumstances are different now. As soon as the schools during their coming-in get to the above-mentioned point of the ridge stretching far out into the Westfiord, they will as a general rule fall in with one or the other of the passing schools of herring, and thus by pursuing the herring, which always keep the middle of the fiord, get farther away from the coast. It is my conviction that the winter-cod goes as far east in the Westfiord now as in olden times, only with this difference, that while near the eastern fishing-stations it does not stay on the fishing-banks as formerly but keeps in deep water or inside the ridge. Every winter while the cod-fisheries are going on at the western fishing-stations, real winter-cod are occasionally caught with deep-water lines even at the most easterly fishing-station, viz, Kanstadfiord; and it is very improbable that these should be scattered forerunners of the great mass of fish coming from the west, which all by themselves should have undertaken the long journey from the western fishing-stations. It seems much more natural to suppose that these scattered fish belong to large

schools which are not so far away, which, however, are not reached by the fishermen, because these schools keep in the very deep water inside the ridge, where the usual fishing implements, nets and lines, cannot be used. It would, nevertheless, be worth while to make experiments here with very long lines during the winter-fisheries. It seems to me, as I mentioned before, very probable that large masses of cod also enter the inner portion of the Westfiord every winter, do not, however, approach the coast, but spawn in the deep water; in accordance with the peculiar spawning method of this fish there would be nothing to hinder this. Old fishermen have assured me that a long ridge slanting on both sides also runs along the middle of the Westfiord, and that these sides are much frequented by fish. This ridge is also in part given on the new fishing-map of the Westfiord, and the observations made by me this year fully corroborate its existence, only its extent, especially in the inner fiord, seems to be much larger than is marked on the map. In the middle, between Skraaven and the inland (Stegen), I found this ridge rising 120–150 fathoms from the bottom; and the bottom was not as in the other deep places of the Westfiord a soft clay, but mixed with gravel and small stones, the very bottom which fish like (so called "fish-bottoms").

I am extremely anxious not to be misunderstood with regard to the above. Whatever I have said regarding the relation of the winter-cod to the schools of herring is by no means to be considered as fully proved facts, but only as suppositions, which, however, have a great deal in their favor. It would be very desirable if accurate scientific investigations of the occurrence of the herring in these latitudes could be made, and especially if more light could be thrown on the so-called ocean-herring, whose young in all probability are those very schools of herring which enter the Westfiord during the winter fisheries. I consider it as beyond all doubt that there is a mutual relation between these two fish, the cod and the herring; and I have already, in my former report, expressed it as my opinion that the normal food of the winter-cod consists chiefly of herring, and that only during its younger stages, as "smaagjed" or algæ-fish, it lives on the various small marine animals which live in shallow water among algæ near the coast. This opinion seems to gain strength by the above-mentioned circumstance that the winter-cod which occasionally approach the Loffoden fishing-stations all during summer have invariably a miserable and haggard appearance.

Regarding the general occurrence of the winter-cod, I have already in my former report expressed the opinion that it does not only approach certain points of the coast for the purpose of spawning, but that it probably approaches the coast along the whole long-stretched northern and western coast of our country at one and the same time, and that the great reputation which the Loffoden fisheries have enjoyed from time immemorial has been caused more by the peculiar orographic formation of this group of islands—their stretching out into the ocean like a long

wedge—than by any greater abundance of fish. Wherever observations have been made during the season when the Loffoden fisheries are going on winter-cod have been observed, and of late many places which were formerly unknown have been observed, and promise excellent winter-fisheries. The information gained by me at Bodö likewise seems to point to the fact that enormous masses of fish spawn every year near the outer islands. On the whole, it may be safe to conclude that wherever large numbers of the "smaagjed" are found near the coast during summer, its parents, viz, the winter cod, will come regularly, at any rate as far as the outer raised bottoms, in order to spawn. I feel convinced that many places where excellent cod-fisheries could be carried on are at present left alone, which to a great extent is caused by the characteristic cleaving of northern people to old customs. The Loffoden have the reputation of being the only place where winter fisheries can be carried on to any advantage; and when the time for these fisheries is near, young and old everywhere prepare themselves for the long and difficult voyage to the Loffoden, there to undergo terrible hardships and return not only without having earned anything, but even with loss, while often quite near, almost at their very door, they might have the richest winter-fisheries. The large gathering of fishermen at the Loffoden fishing-stations makes it very difficult, and at times impossible, to keep proper order; and there are constant complaints of quarrels and fights among the fishermen, causing great loss of fish and fishing implements. The new fishing-law has not served to remove the cause of these troubles, which have increased from year to year, inflicting incalculable damage on the fisheries. This has been particularly the case where fishing was confined to a comparatively small space, *e. g.*, in the East Loffoden. All the more reason is there to inquire whether there are not other points on the coast where remunerative winter fisheries might be carried on, so that the fishermen could be more evenly distributed along the coast. It would seem most natural to leave this to the fishermen themselves, but the force of the old routine is so powerful with most of them that no improvement can be looked for unless the government takes the matter in hand.

B.—REPORT FOR 1871.

As in former years, I shall later give a full account of the course and results of my practical and scientific investigations of the fisheries, and shall for the present only speak briefly of my labors during the summer, my chief object being a proposition to the department regarding a somewhat different arrangement for the next year.

My principal aim this year was to examine the so-called "bank-fisheries," which are carried on on the so-called "Hav-bro" ("sea-bridge") out in the open sea, 12–14 Norwegian miles from Söndmöre and Romsdalen; and I likewise intended to get all the information attainable regarding the other fisheries which are carried on here, especially the

winter-fisheries. For the last-mentioned investigations, which would chiefly consist in an examination of the formation of the bottom, and of the other natural conditions of the places where fishing was going on, I needed no special outfit, but could manage as in former years with a common boat and three men. The case would, however, be different with regard to my intended examination of the banks of the sea. Before I started I drew the attention of the department to the fact that an open boat would be entirely useless, and with such a boat I could not hope for any results. I had an idea that I could carry on my investigations much better if I had a small covered vessel, and I therefore resolved if possible to hire one. I soon found, however, that there was considerable difficulty in hiring such a vessel at this time when every vessel was in use; and when I at last secured an old vessel, which fortunately was not engaged, I could only hire it for a certain time, regardless of the condition of the weather. On this anything but comfortable vessel, manned by four sailors, I made altogether four trips during the summer, two from Aalesund and two from Christianssund, each trip occupying about a week. Unfortunately, the weather was very unfavorable. On my first trip I met with a great calm, so that after having floated about for several days in constant danger of running against one of the many hidden reefs which extend for many miles beyond the outer islands, I did not even get half way to Storeggen, and had finally to return without having accomplished anything, chiefly because I was not prepared for a long voyage and had but a scanty supply of provisions on board.

On my second trip I was more successful. Not only did I reach Storeggen, but I even proceeded 3–4 Norwegian miles beyond this point, or about 20 miles out in the open sea; and although the weather was not particularly favorable, I made several important observations of the full-grown bank-cod, which in no essentials differs from the common winter-cod, and of the young fish of that year. Besides the weather there were a number of circumstances which hindered my observations, circumstances which I had not counted on, and which undoubtedly prevented me from obtaining those important results which under more favorable conditions I might have looked for with certainty. Among these hinderances I must mention the unusually strong current which prevails at Storeggen, at the best fishing-places, and which made it very difficult for me to examine the bottom, or to set and haul in my fishing implements; moreover, I was often in an incredibly short time driven away from the very points where I desired to make observations. It might be said that one way was left open, viz, to cast anchor as the fishermen do while engaged in fishing out here. This I would certainly have done if my boat had, like the fishing-vessels, had a crew of 10–20 men, sufficient to raise the anchor from the great deep (about 100 fathoms). But to do this with only four men could not be thought of for a moment.

Later in the season, when, after long and weary negotiations, I had succeeded in hiring a yacht at Christianssund, with a view of making observations on the outer banks, which had never yet been examined, I was hindered a great deal by the very stormy weather. I deplored this all the more as I had looked for great results from these very observations. I had to hire the yacht for a certain time and pay so much per day whether I used it or not. The weather about this time happened to be extremely changeable. It might be quite calm and suddenly a storm would come up, and this would be repeated several times a day. Although I clearly saw that the weather could not be relied on, it seemed a great disappointment, after having hired the yacht and prepared everything, to lie still on shore; and I therefore resolved to go to sea in spite of the weather, hoping that possibly there might be a change. But the storms continued, there was a high sea and a strong current, so the time which I could actually devote to observations was very limited indeed; and after having braved a terrible storm off Hustadvigen I was compelled to seek the small harbor of Smörholmen, near the Kvitholm light-house. The most provoking circumstance was that the following day the weather was perfectly calm and beautiful, but that I could not make use of it as there was not wind enough to take my vessel out to sea. The next day it was raining and storming again, and I was forced to return to Christianssund. After having rested a day I resolved to make one more attempt during the few days that the yacht was still at my disposal; but I was unsuccessful again, and as the strong current toward the north threatened to drive my vessel toward the dangerous and but little-known waters off Smölen, I had to return without having accomplished anything. On our return voyage we got in a thick fog near the remarkable reefs called the "Nightingales," which extend for miles; fortunately we escaped without injury, with the only exception that some panes of glass in the cabin-skylight were broken by the waves.

Although both these trips were failures on account of the weather, I nevertheless made several observations which were of the greatest interest to me. On my first trip I reached a point in the open sea about 8–10 Norwegian miles west of Christianssund. One forenoon, when the weather was tolerably calm, I noticed a place where the bottom rose considerably, and was very rocky. I immediately let down my boat and put out the line, which I had constantly kept prepared and baited with fresh fish, in order to ascertain whether there were any fish on this elevation, which I took for a continuation of the large ridge ("Storeggen"). But the current was so violent that the yacht was soon driven so far away from the boat that there was the greatest danger in delay, and I was compelled to haul it in although it had scarcely been more than half an hour in the water. I did not expect to see anything on it. All the more surprised was I to find that nearly every other hook had a good-sized fish. My haul was really so large that even my men, who were all old and experienced fishermen, were very much astonished. Seventy-seven

fish on one line is something very unusual even during the best winter-fisheries, and it was thus clearly demonstrated that the wealth of fish in these waters must be very great. The fish were mostly cusk (*Brosmius vulgaris*), large ling, cod, and halibut (*Hippoglossus maximus*), or the same kinds which are caught on the large ridge off Aalesund.

On my next trip I endeavored to strike the ridge in another place; and when, by my soundings, I thought I had reached there I let down my line. When I hauled it in I noticed, however, that it had got into deep water where the bottom consisted of soft clay; the number of fish which I caught was therefore considerably less than the last time, and consisted chiefly of hyse (haddock), skates, and haa (dogfish, *Squalus acanthus*), all fish which prefer a clayey bottom. The weather, unfortunately, prevented me from making any more observations during this trip.

This was all the practical result I could obtain. At the same time I made several observations of great scientific interest. I will here only mention that my examination of the nature and fauna of the raised bottoms has led me to the astonishing supposition that the greater portion if not the whole of the wide extent of ground between the coast and the so-called "great ridge" (Storeggen) has far back in time been raised above the level of the ocean, and that the outer edge of the great ridge has constituted our original coast-line. This supposition so far, it is true, only rests on a few experiments with the bottom-scraper and some frequently-interrupted soundings. But all these observations seem to point so distinctly in this direction that I can scarcely doubt their correctness, although I would have wished to obtain still more convincing data, which unfortunately proved impossible on account of the unfavorable weather. There are likewise several natural conditions which should be more closely examined, not only on account of their scientific interest, but because they most assuredly have a considerable influence on the life of the fish. One of these is the very circumstance which hindered me most in examining the large ridge, viz, the violent current, going in a northerly direction, which, whatever way the wind might be, is found near the great ridge, while nearer the land the current may flow in an entirely opposite direction. In connection with this investigation it was of great interest to me to make thermometrical observations at different depths, which might throw much light on the nature of the different currents. Of all this I could only get a very faint idea, as I did not have the necessary instruments, and even if I had had them I could have done little or nothing on a sailing-vessel.

There is therefore a great deal to be investigated both practically and scientifically; and it was very trying to me as a scientist to know what a wide field for observation was before me and then to lie still day after day undergoing great suffering and unable to accomplish anything. I certainly endeavored to make use of every moment when the weather was in the least favorable; but all these moments when added up would

only constitute an extremely small portion of the long time which I spent on these trips. And still I think that even these sporadic observations have produced some results not only of scientific but also of practical interest, *e. g.*, that off the coast of Christianssund and not near as distant from the coast as at Aalesund rich bank-fisheries might be carried on. I have not the slightest doubt that the same will apply to many other points of our long-stretched coast. But in order to obtain certain results, which can only be done by systematic scientific observations, a common sailing-vessel will be comparatively useless, while a great deal might be accomplished in a short time if these observations could be made from a steamer.

As I of course do not expect that the government will risk the considerable expense, and place a steamer at my disposal, I have thought of a way in which this difficulty might be solved without any great increase of expenditure. I have an idea that the examination of the raised bottoms might easily be connected with the soundings made along our coast, which have been made for several years from a government steamer, and which are to be continued. I consider it absolutely certain that my investigations would not only be very closely connected with these soundings but would also serve to supplement these soundings and aid in reaching the object in view, viz, a complete knowledge of the formation and nature of the bottom. Various conditions can only be examined very imperfectly with the sounding-line, other apparatus and another method of taking observations being required.

I will here only mention that in the map of the Söndmöre district published from these surveys the large ridge is always marked as a solid rock, which, according to my observations, is an error; it is not a solid rock, but consists of numberless large and small loose stones rounded off and polished by the constant action of the waves. It is quite natural that mere soundings could not give a correct idea of the bottom, as only a clayey or sandy bottom will leave traces on the line and plummet, while stones or rock will not leave the slightest trace. It is well known that a bottom consisting of loose stones is always considered the best fishing-ground, much better than when it consists of solid rock; so that from a mere practical point of view it is of the greatest importance to know the exact nature of the bottom. A sounding-line will not suffice to ascertain this, but bottom-scrapers are required which will bring up specimens of the bottom. In order to ascertain in how far a bottom may be suited for the sojourn of large numbers of fish it is very important to examine the fauna of the bottom, which also can only be done with the bottom-scraper; it is also desirable that experiments be made with various fishing-implements.

If all these investigations are combined with other purely physical experiments regarding the direction of the current and the degree of temperature at the different depths, I believe that we would obtain a much more complete and useful picture of our sea-bottoms than mere

soundings could furnish. Other countries have fully recognized the importance of such thorough investigations. Not to speak of the grand, chiefly scientific investigations made by the English government, the United States of North America have recently combined the most extensive physical and zoölogical observations with the surveys of their eastern and southern coasts, which have already yielded many important practical and scientific results.

It is self-evident that if these investigations are to be successful, and are, by supplementing each other, to yield the desired result, the work of sounding must be somewhat modified, so as to leave sufficient time for other observations. The number of soundings made within a certain given time will consequently be smaller than when no other observations are made. But I think that these observations are so important that some time might well be devoted to them.

The expenses of this change of method would be but very small. The crew of the steamer would probably have to be increased by two or three men, to be placed at my disposal. I ought as regards my board to be placed on the same footing as the officers engaged in sounding; and as I scarcely could spend all my time on the steamer during its whole cruise, my traveling-expenses to and from the steamer ought to be refunded. An appropriation should likewise be made for the necessary apparatus, &c.

C.—REPORT FOR 1872.

I shall briefly report the observations made by me during the summer, for which an increased appropriation had been allowed to the coast-surveying expedition.

In my preliminary report of last year on my practical and scientific investigations of the bank-fisheries near Söndmöre I spoke of the many difficulties in the way of these investigations, and asked the department if it was not possible to combine my observations with the systematic soundings of the sea for which the government furnished a steamer. I mentioned the fact that other countries, *e. g.*, England and the United States, had combined zoölogical and other scientific investigations with their coast-survey. The government entered upon my ideas, and I therefore resolved to make another attempt this very summer, although the location where this year's surveys were to be made, viz, the sea outside of the Jader, is, properly speaking, beyond the limits of the well-known fishing banks. It was to be supposed, however, that the almost uninterrupted row of banks which extends along our western coast would also stretch farther south; that new fishing-places might thus be discovered, and that my zoölogical observations would in any case yield interesting scientific results. As that portion of the sea where the surveys were to be made is in close proximity to the spring-herring district I was commissioned by the department also to give special attention to the herring, and, if possible, to throw new light on the still somewhat

dark question of the nature and migrations of the herring. This I promised to do, with the intention of communicating all the results of my observations of the herring to Mr. A. Boeck, whom the government had specially commissioned to investigate the herring-fisheries.

As soon as my official duties at the university had come to an end, and I had procured the necessary instruments and apparatus, I left Christiania by steamer for Stavanger on the 27th June. Here I found the coast-survey steamer Hansteen, and the day after my arrival at Stavanger I went on board.

My functions were to be those of a zoölogist, and a special place on the ship had been arranged for me. But besides my zoölogical investigations, I also intended to make practical observations on the fisheries, especially with the view of ascertaining whether by means of the soundings new and suitable fishing-banks might not be discovered. In that portion of the sea where soundings had to be made (the portion near the coast had already been surveyed before I came) the bottom proved but little suited for any kind of fisheries. At a depth of 140–150 fathoms it extends for miles without exhibiting any perceptible change. Everywhere you find the same soft tough clay, and this kind of bottom is the very worst for the fisheries. Only at a considerable distance from the shore (about 20–30 Norwegian miles) the bottom rises somewhat toward the so-called "reef," a continuation of the Jutland reef, and gradually changes its character. Instead of the soft clay, void of animal life, we find first clay mixed with sand; then a fine yellow sand, which near the reef is mixed with gravel and small stones. The water here is only about forty fathoms deep, and keeps at that depth for a considerable distance farther out. After I had with my bottom-scraper brought up a portion of this bottom and found it to be suitable for fish, I one fine day when the steamer was lying at anchor let down several lines, and although the time of the day was not the one most favorable for fishing (it was noon, and the sun was shining brightly), I soon hauled in some very fine cod. I was much interested in examining this so-called "reef-cod," which formerly was considered as a separate species, said to live near the reef all the year round. I found that it did not differ in any respect from the winter-cod or skrei, with the only exception that the generative organs (roe and milt), as might be expected about this season of the year, were not yet fully developed. It is well known that occasionally genuine winter-cod (skrei) are caught outside the Jader and on the Stavanger coast, and this had been especially the case last winter. A great number of these winter-cod certainly keep near the reef during the summer, and are then called "reef-cod." If this "reef-cod" was a separate species, peculiar to the reef, one would also find young "reef-cod" besides the older fish. But this is not the case. The fish found here are all of an equal size (all the specimens caught by me measured about forty inches, and were therefore all full-grown) and old fish. The younger fish have quite a different place of sojourn; here, as everywhere, they

are found on the algæ-bottoms near the coast, and are known by the name of "algæ cod," "small-cod," &c. The youngest fish I observed several times in that peculiar transition period when they go under the medusæ. On calm and clear days, when carefully watching the large number of medusæ which were floating past our steamer, I was always sure to see some with the little fish sticking out underneath. But I only succeeded in catching two of them, which, however, convinced me that they were really young cod, and not the young of other fish. All this I had already observed during my former journeys to the Loffoden, so that all my investigations could only be of interest as corroborating my former observations of the development and mode of life of the cod.

As regards the zoölogical results of my observations, which were obtained incidentally by means of the bottom-scraper, they were quite considerable, and all the more interesting, as so far at least these portions of the sea had never been explored by a naturalist. I was specially interested in gathering specimens of the different bottoms, with a view of ascertaining the influence of the bottom on the development of animal life. The results of these investigations will be published in the reports of the Academy of Sciences ("*Videnskabs selskab*") as soon as all the material has been collected and arranged.

But as it was likewise my desire to make practical observations of the fisheries, and as I soon found that that portion of the ocean where the surveys were to be made was but little suited for such observations, I considered it my duty to change my original plan, and exchange the comfortable life on board the steamer for the more difficult and dangerous method of making observations from an open fishing-boat. I was furthermore induced to take this resolution as two weeks after I had gone on board the Hansteen festivities began in honor of the Crown Prince (our present King) in connection with the unveiling of the Harold monument, which would take the steamer for some time out of its regular line of duties. I therefore respectfully bade adieu to the life on board and the pleasant company of Lieutenant Wille and Lieutenant Kröpelin, and with all my apparatus left the Hansteen on the 14th July to continue my observations on my own account.

Since I was not, as in my previous voyages, in a cod-district, but in a herring-district, my attention was of course chiefly devoted to the herring. It was my special object to examine the so-called fat or summer herring, because I had a lingering suspicion that its true nature had not been properly described by older naturalists and by Mr. Boeck. With this intention I took my first station in the city of Stavanger, from which point I made excursions to the different fiords in the neighborhood. The Stavanger fish-market likewise afforded ample opportunity for examining herrings, which about this time were brought to town in large quantities. After these observations had come to an end, it was my intention to visit one of the outer fishing-stations where the spring-herring fisheries are going on during winter, partly to get information

regarding the spring-herring fisheries, partly to make if possible more direct observations. I chose for this purpose the fishing-station of Hvitingsö, lying far out in the sea, an old and well-known spring-herring place, where I made the best arrangements I could for investigations during the time that was still left before my lectures at the university commenced. From here I made excursions in various directions, principally examining the bottom in those places where the herring-fisheries are carried on, but also gathering much interesting and valuable information from experienced fishermen. It was of great interest to me to observe the enormous number of young herrings which at this time filled all the sheltered sounds and inlets, and which, on closer examination, proved to be almost exclusively young spring-herring, and, as could be judged with certainty from their size, this year's young ones. The fishermen of these regions know well how to distinguish these young herring from the "brisling" (the sprat ?), whose size they almost reach, and call them by a special name, viz, "*Æsja.*" They were used partly for fishing-bait, partly for bait for eel-traps, and were caught, whenever occasion demanded, with fine nets in the quiet grass-grown inlets. When somewhat later I examined the "brisling" brought to the Stavenger fish-market from various parts, I always found mixed with them a large number of these little spring-herrings. There must this year have been a remarkable abundance of these young herrings, as the fishermen of Hvitingsö also assured me that they could not remember so large a number of young herrings ever since the memorable rich spring-herring fisheries. From this circumstnnce we are justified to conclude that a large number of spring-herring must have been near the coast and must have spawned here. The failure of last year's spring-herring fisheries is therefore not caused by any decrease in the number of herrings or by a change in the migrations of the herring, but solely by the fact that from some reason or other the great mass of herrings have not come so near the coast as formerly, but have spawned farther out at sea on the outer bottoms. This opinion was confirmed by testimony received from various quarters. All the fishermen here are agreed that great masses of herrings came near the coast at the usual time, which could be seen from the extraordinary number of whales and birds, and that for a time everything indicated that there would be large herring-fisheries near Hvitingsö. But people waited too long, hoping that the herrings would come to the usual fishing-places, and the consequence was that the herrings spawned with the greatest ease and comfort on the outer bottoms, and had actually finished spawning when the fishermen attempted to catch them farther out at sea.

As a further proof of the correctness of these statements, I will mention what a very reliable fisherman, the pilot Henni Larsen, has told me. Shortly before the close of the herring-fisheries this man was out line-fishing on the outer bottoms and caught an unusual number of large cod, so that his boat was loaded in a very short time. The most remark-

able circumstance, however, was this, that all these fish had their stomachs filled with herring-roe which they threw up in great quantities as soon as they were put in the boat. A considerable number of herring must therefore have been in these waters if such an enormous mass of roe was left as to cover the bottom, as it must have done. It is nothing new that cod and other fish of prey devour a great deal of the flowing roe; and it is an old experience that after the herring-fisheries a large number of cod come to the spawning-places, especially on the west side of the island of Karmö. Nor is there any cause to be alarmed at this. In accordance with the laws of nature only a certain portion of the enormous quantity of spawn left by the schools of spring-herring is destined to develop, while the remainder is intended as food for fish and other marine animals, which I have also shown to be the case with the roe of the cod. I feel convinced that the usual number of herrings have also visited the coast this year and have spawned in suitable places. Even if the great mass of spring-herrings have this year and partly also in the preceding year, from some unknown cause, spawned at a greater distance from the coast than usual, this does not prove that they will do so always, much less that they will leave the coast entirely. I think there is no absolutely certain indication of such a sudden change in the migrations of the herring. The idea that the Bohuslän herring-fisheries should have any connection with our herring-fisheries, seems to me to be still more absurd. I think, on the other hand, that there are many reasons for encouraging the hope that the herring-fisheries on our western coast, under more favorable circumstances, will also in the future prove successful in the old fishing-places, of course with slight variations in the number of fish caught. The careful observations of the summer-herring which I have made this summer have confirmed this opinion.

With regard to the nature of this herring (the "summer-herring") very erroneous ideas have been prevalent among naturalists, as it has been considered as a different variety from the spring-herring, or as a separate species of herring. Mr. Boeck has spread this erroneous opinion by repeating the statement of Professor Nilsson which is based on a mistake,* that the summer-herring spawns in autumn while the spring-herring spawns in winter and early in spring. If this were really the case, that the summer-herring spawned at such a different season of the year, it would, in spite of its close resemblance to the spring-herring from a zoölogical point of view, have to be considered not only as a different variety but rather as a separate species. There may be herrings which spawn in autumn, and this is especially the case with the so-called "Kulla-herring," found on the Swedish coast of the Kattegat; but this different spawning-season is caused by different natural conditions. On

* Professor Nilsson's statement is, *verbatim*, as follows: "This kind of herring (the Norwegian summer-herring) resembles, as has been said before, the Kulla-herring, and is, like this one, said to approach the coast in July and August and to spawn in September and October." Skandinavisk Fauna, T. 4, part 3, p. 511.

a coast where herrings occur which spawn in spring, there cannot be any which spawn in autumn, or *vice versa*. Any one who will calmly think about the matter will be convinced that the summer-herring cannot possibly spawn in autumn.

The fatness and excellent quality of the summer-herring is caused by the circumstance that, as has been said, it "has fat instead of roe and milt." Zoölogists may succeed in finding underneath the fat in the lowest portion of the body those organs in which roe and milt are formed, but these organs are as yet so little developed, that it could not be definitely decided whether they in any possible way could reach maturity as early as autumn. Nor do the fishermen know anything about such herrings which spawn in autumn; and when asked at what time the summer-herring spawns, they will generally express the utmost astonishment at this question and say, "Why, the summer-herring don't spawn at all; it has not got roe and milt, but only fat." They consider this as an established fact; and have never thought about it that every and any kind of fish, in order to exist, must have the faculty of propagating the species. The fact of the matter is that when the summer-herring spawns—and it does so, of course, at some time—it is no longer a summer-herring or fat-herring whose body is filled with fat and not with roe or milt.

Which are then the real facts in the case? Why, simply these: *The summer-herring is not, as has been formerly believed, a separate variety of herring, but nothing more nor less than the offspring of the spring-herring of different ages, and must, therefore, according to the laws of logic, at last become a genuine spring-herring.*

This opinion already previously entertained by me, and which in a very striking manner was confirmed by the observations made by me during this summer, appears in reality so self-evident, that it seems very strange that no ichthyologist has so far hit upon this very simple explanation. The chief cause of this must be the mistaken idea that the summer-herring comes into the fiords and bays for the same purpose as the spring-herring, while, as every one who is acquainted with the herring-fisheries will know, it does not come at all for the purpose of spawning, but in order to feed on the various small marine animals gathered here by the current.

By examining the different fat herrings which are brought to the fish-markets of our western towns, their size will be found to be very different. They have, therefore, as is well known, got different names in the trade, *e. g.*, "Christiania herring," "middle herring," "merchants' herring." These different sizes represent the different ages, which may also be recognized by the different development of the generative organs. If the smallest Christiania herring is laid side by side with this year's young of the spring-herring, the so-called "Æsja," we will, if we look away from the difference of size, find the most complete agreement in all particulars, so that no one would ever consider them as be-

longing to different varieties, just as little essential difference can be noticed between the "Christiania herring" and the "middle herring" and the "merchants' herring." We have, therefore, before us all the successive stages of the spring-herring: (1) this year's young ones, *Æsja*; (2) the young ones of the preceding year, *Christiania herring*; (3) the young ones of the year before that, *middle herring*; (4) the young ones of the year preceding the one last mentioned, *merchants' herring*; and, finally, the young ones of the fifth year, the genuine *spring-herring* or "*Graaben herring*."* This must not be understood in this way, that all the fish called "Christiania herring" are of one and the same year, those called "middle herring" from another, and those called "merchants' herring" from a third year. It is well known that all the transition-stages are found among these different kinds of summer-herring (thus there are small and large "Christiania herring," small and large "middle herring," small and large "merchants' herring") which has its natural cause partly in the fact that the spawning of the spring-herring and, consequently, also the development of its young, is extended over a considerable part of the winter and spring, partly in the fact that not all fish reach the same size in the same given time. A fish, *e. g.*, which, according to its size, ought to be counted among the "Christiania herring," may be just as old as another which, to judge from its size, would pass in trade as a "middle herring," &c. But as a general rule the herring caught during summer can be classed under the four above-mentioned heads.† Of these neither the "Æsja" nor the "Christiania" herring will be able to propagate during the following spring, which may be supposed, if one sees how little developed the generative organs are. Of the "middle herring" only very few are found with whom such a thing is possible; but of the "merchants' herring" a larger number may by this time have become capable of propagating. It will then make its appearance at the same time as the spring-herring, and as in that case it will, like the spring-herring, have fully developed roe and milt, it will not generally be considered a fat herring, as formerly. It will then pass for young spring-herring. It is quite probable, however, that on closer examination, especially when these young herring, spawning for the first time, are found in large numbers among the older spring-herring, some difference will be discovered, caused chiefly by the circumstance that they have not yet become familiar with life out in the open sea, to which the older spring-herring are accustomed, and which they will not try until the spawning is over. It is also possible that the spawning of these younger herrings does not agree entirely with that of the older herrings in point of time, but that it possibly takes place

*See, with regard to these names, Sars's correction in the report for 1873, p. 41, foot-note.

†Of these four different classes I have preserved excellent specimens in spirit-of-wine, and sent them to the Zoölogical Museum of the Christiania University, labeled in accordance with my views as given above.

somewhat earlier. I was thus very naturally led to think of the so-called "mixed herring," which has frightened people so much, because its occurrence was considered as an indication that the genuine spring-herrings would disappear. With regard to this "mixed herring" the fishermen could not mention any other difference between it and the spring-herring save that it is fatter, therefore of a better quality, only somewhat smaller, and spawns a little earlier. Although I have not personally examined this so-called "mixed herring," I nevertheless will here express my conviction that it is nothing else but summer-herring in its transition-stage towards "Graaben" herring; in other words, the youngest spring-herring, which in the following year will return as genuine "Graaben" herring.

But, people will say, the "mixed herring" is a kind of herring formerly quite unknown, which only has made its appearance on our coasts during the last few years. This, in my opinion, erroneous view of the matter, is explained in a very natural manner by the circumstance that formerly no attention had been paid to it, because it was mixed with the "Graaben" herring, while just during the last few years it has been less mixed with these, since the great mass of the older herring ("Graaben herring") coming in from the sea have spawned on the outer bottoms. I can, therefore, not see in the unusually large number of these "mixed herrings," which have made their appearance during the last few years, any indications that the spring-herrings will disappear; on the contrary, it seems to me to indicate the very opposite.

As will be seen from the above, the conditions of development and mode of life of the herring correspond in every respect with the results of my careful observations of the life of the cod. Here, likewise, it was thought that there were two different varieties, one belonging to the open sea and one to the coast. I have proved, however, and as I think in an incontrovertible manner, that the coast variety is the same fish as the open-sea variety, only differing in age. Just as the winter-cod, or offspring of the skrei, spends the first years of its life near the coast and only at a more advanced age migrates to the distant banks, thus also do the offspring of the spring-herring spend the first years of their life near the coast, and under the name of "fat-herring" gather in large schools during summer in order to feed on the numerous small marine animals which current and wind have piled up in the different fiords and bays.

Since the determination of the fact that the summer-herring, or fat-herring, is not a species or variety of herring different from the spring-herring, but only its offspring at different ages, has been sufficiently proved, our views of the future of the spring-herring fisheries must be considerably modified. If, as has been supposed, the spring-herring fisheries on our western coast would cease completely, because the schools of spring-herrings either decreased in number or migrated to other coasts, a corresponding decrease of the summer-herrings ought to

be noticed; but this is not the case. The summer-herring fisheries were particularly rich this year on the ledges of Stavanger; at any rate, no decrease could be noticed, but rather an increase.

It is well known that Mr. A. Boeck has, chiefly from historical data, reached the result that a so-called "herring period" should now have come to an end, and that consequently there would be a period of poor herring-fisheries. The same signs are said to show themselves now as when many years ago the herring-fisheries came to an end. No one is more ready than I to acknowledge the great merits of Mr. Boeck in having compiled the truly astonishing number of historical documents which had never before been printed, the collecting and arranging of which must have taken considerable time and trouble. I likewise acknowledge the great value of such documents as materials for a history of the herring-fisheries. But I believe that in using these documents, whose completeness and reliability decreases the farther back they date, we ought to be very careful, and, at any rate, first and foremost consider an accurate and exhaustive knowledge of the *natural* history of the herring as the only really sound basis of our opinions. It is not at all decided to my mind whether there are really such regular "herring-periods." If we wish to talk of real periods, it is not sufficient to know that once upon a time the herring-fishery proved a failure, and that after a number of years it revived again. This must be repeated several times under similar conditions in order to justify us in speaking of regular "herring periods."

D.—REPORT FOR 1873.

As in the preceding year, I again intended to make use of the regularly established connection between the investigation of the fisheries and the coast-survey, and therefore resolved to go again on board the steamer Hansteen, and stay there as long as anything worth observing should show itself. I considered this all the more important this year, as surveys were to be made near the southern herring-district and as thus I would be enabled to gather valuable information regarding these fisheries.

On the 6th of June I left for Hangesund, where I arrived on the 8th, and immediately went on board with all my apparatus. On the following day we went out to sea. After soundings had been made at different points outside the herring-district, I arrived at an agreement with First Lieutenant Wille, according to which we would first follow a line from the coast to the reef, lying about in the middle of the district which had been selected for this year's surveys. This line ran in a westerly direction from the Selbjörn's fiord. On this trip, which occupied several days, the bottom was carefully examined with the bottom-scraper, specimens brought up by the sounding apparatus were likewise examined, and frequent thermometrical observations were taken at different depths. Besides this, a careful comparison was instituted for every point with

the former lines followed toward the reef during this and the preceding year by following parallel lines. I thus found that this part of the sea is much more monotonous than I had expected. Both the nature of the bottom and the depth, the animal life, the temperature of the water, and other natural conditions corresponded exactly with the results of observations made in following other lines, so that one could generally say beforehand from the location what depth and what bottom a certain place would have. I was thus enabled by this one trip to get a complete idea of the natural conditions of this whole district; and I consequently saw but little use in watching the soundings, from which I could only look for very insignificant results as far as *my* investigations were concerned, at least in comparison with the great amount of time spent. After I had been about eight days on board the steamer I determined, as last year, to leave it and endeavor to make observations on my own account on such points of the coast as I thought would be most suitable. On account of the season, these observations could, as during the previous year, only refer to the so-called "summer-herring" and the tender young ones of the spring-herring, with a view of still further corroborating the opinion advanced in my former report, that all these fish only represent different phases of one and the same herring. It was likewise my desire, if possible, to gain some information regarding the winter-fisheries, partly by direct examination of the bottom, partly by listening to the accounts of experienced men.

My investigations commenced at Bukken, three Norwegian miles south of Bergen, from which place I made several excursions, especially in a southerly direction toward the mouth of the Korsfiord, where last winter there had been considerable fisheries of so-called "mixed herring." During my stay several hauls of summer-herring were made, of a smaller size but of a remarkably good quality, which I state here with considerable satisfaction as refuting the opinion held by some people that the herring coming to our southwestern coast has deteriorated in quality. After having staid here about three weeks, I went farther south to the old and well-known spring-herring fishing station Espevær, at the mouth of the Bömmelfiord, where I staid about one month, and where I carefully examined the bottom, likewise gathering information concerning former herring-fisheries. At the last-mentioned place I had an excellent opportunity of observing the summer-herring and the conditions under which they approach the coast, all of which went to still further corroborate my former view regarding their relation to the spring-herring; a view which I found, to my great satisfaction, was shared by experienced fishermen and other persons well acquainted with the fisheries. During my stay considerable hauls were made, in the beginning nearly exclusively large "merchants' herring," later mostly herring of different sizes, but all of a very fine quality. On my arrival at this place I could already predict the speedy approach of the herrings from the

enormous quantity of small marine animals which had come in with the current; and I was not disappointed. The herrings staid for a long time in the bay of Vespestadvaagen, which cuts deep into the west side of the island of Bommelö, where very rich hauls of herrings were made even long after the little marine animals had disappeared from the outer islands.

As I knew that last winter considerable spring-herring fisheries had been carried on, though only for a short time, at the fishing station of Lyngholmen, on the other side of the fiord, I took an interest in examining that locality in order to compare it with Espevær, where this year there had been no spring-herring fisheries. I therefore stationed myself there for some time, and took several excursions, both in a westerly direction round the Nyvarden light-house and farther up the fiord. It is true that during my stay I did not succeed in witnessing any summer-herring fisheries; but I had occasion to make another observation which was of great interest to me, because I had heard that the spring-herrings during the last winter-fisheries had "whitened" the sea, *i. e.*, had spawned. The sea was everywhere filled with young herrings, which roamed about in dense schools partly near the land and partly farther out in the fiord, followed by flocks of sea-gulls and terns. In one of the well-known fishing-places east of Lyngholmen, called Eltrevaag, people thought one day that they could see many young cod ("*mort*"), and let down a small net, but when it was hauled in, it was found to contain nothing but young herrings, which were so small that most of them slipped through the meshes of the net.*

Also, during the continuation of my journey up the fiord, I repeatedly noticed large schools of the same year's young ones even as far up as the sounds, where I was told they had never been seen before, at any rate not in any large number. I must lay stress on the fact that these fish were not young "brisling." The fishermen know very well how to distinguish the two by their size and other characteristics.

Before I concluded my investigations for this year, I desired for comparison's sake to visit a few points in the northern herring district where the fisheries last winter had been of a very peculiar character, the herrings staying away from the old and well known fishing-stations and coming in considerable number to places where in former years there had been no fishing at all.

---

*I here take occasion to correct a mistake made in my last report (for 1872). I had supposed that the small herrings, about the size of the "brisling," which at Stavanger is called "Æsja," were the young ones of that year. The observations made by me this summer, however, have inclined me to the opinion that they are older herrings, young ones from the preceding winter. Another year must therefore be added to the time which it takes the herring to become fully matured; therefore, first year, "musse"; second year, "æsja" (bladsild); third year, "Christiania herring"; fourth year, "middle herring"; fifth year, "merchants' herring"; sixth year, "spring-herring."

As my first station I selected Florö, from which place I intended to visit Kinn and the small outer islands in the neighborhood. At Florö my observations were chiefly directed to the young herrings, which I found here in large numbers both near the coast and farther out at sea, where they were chased by different fish of prey, chiefly small mackerel. I had no opportunity, however, to examine the summer-herring, as the fishery had closed before my arrival. On account of the stormy weather I had to abandon my project of visiting the outer fishing-stations near Kinn, and determined instead to visit some points on the Nordfiord, where I knew there had been rich spring-herring fisheries last winter. As I thought Moldö would be the most convenient station for me, I went there. From Moldö I made several excursions farther out at sea and along the coast, especially along the south and west coast of the island of Vaagsö, where I visited the fishing-stations of Torskangerpollen, Buevigen, Hovdevaagen, and Svartteigene, all well known on account of their winter-fisheries. My chief object was, if possible, to throw some light on the following question: "Is it possible that the constant use of fishing-implements during winter (especially the nets now in use) within a limited extent of water causes large masses of dead herring to lie and rot on the bottom, and thus make the bottom so full of corruption that it does no longer form a suitable spawning-place for the following winter?" I was all the more eager to investigate this matter, as several men of experience really thought this to be the cause why the herring-fisheries had proven failures in formerly good fishing-places. Although my observations did not positively confirm this view, I nevertheless believe that it is a matter which deserves attention in the future. But as only observations made *during* the fisheries could lead to certain results, I do not feel at liberty to express any definite opinion.

From Moldö I had intended to visit one of the northern stations near Stadthavet, but as the season was far advanced and the weather was very stormy, so that I could not have accomplished much, I had to abandon this trip and conclude my observations for this year. After having staid eight days at Moldö I took the steamer going south on the 18th of September and arrived in Christiania on the 21st.

After having in the above given a short account of my journey and the plan which I had followed in my investigations, I shall endeavor in the following to give a more detailed account of the more important results and the opinion regarding the herring and the herring-fisheries to which these results have led me.

During my stay on board the Hansteen it was my chief object to examine the deep basins outside of the herring district, where it is generally supposed the spring-herrings live during the time they are not near the coast. Such an investigation I considered to be of special importance at the present time, as possibly it might furnish some explanation of the remarkable decrease of the spring-herring fisheries on our western coast during the last few years, and at the same time give us

a better insight into the natural history of the herring. My investigations, made during my stay on board the Hansteen, had led to a definite result in this matter, which, at any rate, throws more light on the natural history of the herring. This result is of a purely negative character, but nevertheless it is undoubtedly of great importance, as in connection with the observations of the last two years it leads to a definite and, as I think, more correct and more important opinion regarding the nature and migrations of the herring.

As I have said above, it was quite a common opinion among modern zoölogists that the spring-herrings when not near the coast, therefore during summer and autumn, live in the deep valleys or basins of the sea, off that same coast where they spawn during winter and spring, an opinion which I shared as far as the cod was concerned.* This opinion was first advanced by Professor Nilsson, and is chiefly based on the great difference exhibited by the various herrings found on the Swedish coast. Also regarding *our* coast, similar views have been expressed, viz, that the spring-herrings, when not near the coast, live in the great deep, chiefly in the very deep trough, which, varying in breadth from ten to fifteen Norwegian miles, extends along our western coast as far as Stat and empties into the North Sea.† The results of the investigations of the depths of the sea, which of late years have been carried on, on a large scale, do not seem to contradict this opinion, since it has been shown that even in the great deep there may be a rich and varied animal life, so that the herring would find sufficient food all the year round even at the greatest depth. These same investigations, however, have proved that the nature of the deep is not the same everywhere, but that just as on the dry land there are barren places with very little animal life—submarine deserts—which are traversed by the greedy schools of fish, but which could never be their permanent place of sojourn. This is chiefly dependent on the nature of the bottom, and, to some extent, on the varied depth. Where the nature of the bottom is such as to allow the smallest animal to live and develop in any considerable quantity, animals of a higher grade, which live on these, will make their appearance, and from the same reason the place will become a convenient place of sojourn for fish and other large marine animals. But where the conditions are not favorable for the development of lower animals, the higher animals (*e. g.*, fish) cannot live.

On account of this actual dependence of the various marine animals on each other, it will be comparatively easy for a zoölogist to decide from the nature of the bottom whether it will be suitable as a permanent place of sojourn for fish. The investigations made by me on board the Hansteen during this and the preceding year have sufficiently

* I have, however, as will be seen from my second report, changed my opinion, as I consider the large banks off the coast as the home of the winter-cod.

† See A. Boeck's work: "Om Silden og Sildefiskerierne" (on the herring and the herring fisheries), p. 47.

convinced me that along our southwestern coast there is no deep basin of a nature calculated to form a place of sojourn for the enormous mass of spring-herrings during that part of the year when they are not near the coast. The whole extent of bottom from the outer fishing-banks to the reef forms a very monotonous plane at an average depth of about 150 fathoms, covered everywhere with a thick layer of loose, sticky clay, a portion of which in all probability fills the lower depth of water; and this kind of bottom is the least suited for the development of animal life. A careful examination of the specimens of bottom brought up by the sounding-apparatus and the bottom-scraper has fully corroborated this. This whole portion of the sea must be considered a desert where only here and there some animals of a low grade (*e. g.*, worms) eke out a miserable existence. Only where the bottom at a distance of 12–14 Norwegian miles from the coast begins to rise toward the reef it gradually assumes a different character, becoming firmer and more mixed with sand; but even here animal life is not very strongly developed. On the reef itself the bottom chiefly consists of fine brown sand, which is so fine that it is almost impossible to get anything off with the bottom-scraper.

From the above it will be clear that the schools of spring herrings which usually spawn on our western coast, cannot possibly, as was formerly supposed, live at the bottom of the deep, immediately outside of the coast waters, but must come from some other place. If one asks whence these immense schools of fish come which year after year visit the same coasts at the same time, to disappear again without leaving the slightest trace, the answer might be returned that for the present this cannot be decided with absolute certainty; in fact, not until our *whole* coast has been carefully surveyed, as has been done with regard to its southwestern portion. One might then expect to find further north the deep basins whence they come.

It is my opinion, however, that even such an exact knowledge of the bottom along our widely-extended coast would not bring the problem any nearer to a solution. As long as the surveys are made at the same distance from the coast as hitherto, they are still far from those places where the spring-herrings generally stay. All that we can for the present consider as certain, and which also agrees with the observations made during the fisheries, is this, that the spring-herrings in the southern district come from the northwestern part of the ocean, as great schools of herrings have been seen before the beginning of the fisheries in that direction as far as 15 (Norwegian) miles out at sea, and in one case even as far as 20 miles.* The schools of spring-herrings in the northern district (at Kinn) also come from this direction; and even to the great herring-fisheries in Nordland the same rule seems to apply, which seems self-evident from the successive migration of the fisheries

*See Boeck's work, "Om Silden," &c. (on the herring, &c.), p. 47.

in a southerly direction. If we look at a map we find that all these lines point to the large and so far but little investigated portion of the sea between Scotland, Iceland, and Norway. Many other reasons have determined me to consider this as the proper home of the spring-herring. Occasional soundings made in that portion of the sea have shown that the depth is certainly very great, so great that fish like the spring-herring, which undoubtedly pass part of the year near the surface, could not be supposed to find an inviting place of sojourn at the bottom of this basin. There is in my opinion no necessity for supposing this to be the case.

When thinking about the above-mentioned hypothesis advanced by many modern zoölogists regarding the place of sojourn of the spring-herring, it has always appeared to me very improbable and contrary to nature that a fish like the herring, whose whole build and inner organization (its compressed wedge-shaped form, its large swimming-bladder, wide respiratory organs, &c.) seem to be calculated for a free and roving life near the surface of the sea, should follow such a mode of life only during the short time of its spawning season, but should all the rest of the year hide in the deep valleys of the ocean. Still less probable did this seem to me after it had become perfectly clear to my mind that the so-called summer-herring is not, as zoologists formerly believed, a different variety from the spring-herring, but simply the same herring at a different age. The roving mode of life of the summer-herring can easily be observed on our coasts during summer and autumn. It will soon be seen that these herrings do not keep in the deep, unless it were during the time that the full-grown herring (the spring-herring) leaves it, and that they then are again chased away when the old herrings return to the deep. The food of the summer-herring consists almost exclusively of small crustaceans of the order of Copepods swimming about freely, the so-called "herring-food," which, on account of the unusual quantity of fatty oil contained in their bodies, are very nutritious. All these small crustaceans keep more or less near the surface of the water, never at the bottom, and it is their very wealth of oil which enables them to keep continually near the surface.

It is true that there are similar crustaceans near the bottom, but in the first place their number is very small compared with those near the surface, and in the second place they do not contain so much oil, which circumstance is really what makes crustaceans such an important article of food for fish. The spring-herrings would therefore scarcely find sufficient food at the bottom, unless they would (which, however, is highly improbable) be satisfied with a totally different food. The surface of the sea, on the other hand, will all the year round richly supply them with that food to which they have been accustomed from their earliest age.

It is likewise my conviction that the spring-herrings use exactly the

same food as the summer-herrings, viz, small Copepod* crustaceans, which freely float about in the water, from which it follows that, like the summer-herrings, the spring-herrings must spend the greater portion of their life near the surface of the water. It is well known that these small crustaceans ("herring-food") are not only found near the coast, but everywhere in the open sea, and it is a fact proved not only by many sailors and fishermen, but also by zoölogists (*Kröyer*), that that very portion of the sea mentioned above is particularly rich in these small animals, so that by their enormous mass they will color the water for miles and even furnish an important article of food to the monsters of the deep, the whales, &c. There would consequently be no lack of food in these regions for the enormous schools of spring-herrings which visit our own and the Scottish coasts for the purpose of spawning; and I consider it therefore as highly probable that this portion of the sea is the true home of the spring-herring.

The objection might be raised that if this were really the case schools of herring ought to have been seen here. But it must be remembered, in the first place, that this portion of the sea has so far been but little investigated, and in the second place, that it cannot reasonably be supposed that the herrings are gathered here in those dense schools which we see when they come near the coast in order to spawn, but that in order to obtain the required amount of food they have to live more scattered, and be distributed over a very wide area. It must likewise be borne in mind that only in the height of summer, and when the sea is as smooth as a mirror, the small crustaceans will be found near the surface of the water, while when there are even the smallest waves they immediately go down several feet, in which case the scattered schools of herrings are of course withdrawn from observation. Not till the middle of winter, when roe and milt develop, do the scattered schools, driven by their instinct, gradually gather and approach the coast in order to spawn on suitable bottoms. Thus, the scattered fish gather into schools and form enormous compact masses of densely packed herrings, a so-called "herring mountain," which, like a solid wall of considerable dimensions, extending not only in a horizontal but also in a vertical direction, approaches the coast. It will be easily understood that the great masses of spring-herrings while approaching the coast must generally accommodate themselves to the formation of the bottom; *i. e.*, follow the deep troughs or valleys.

The fact that they approach the coast chiefly in a southeasterly, and

---

* A. Bœck has also (see his work, "Om Silden," &c., p. 46), by a microscopic examination of the contents of the entrails of recently caught spring-herrings, found pieces (chiefly feelers and feet) which undoubtedly had belonged to the Copepods. But as he started from the supposition that the spring-herrings come from the deep, he also supposed that these remains could only belong to such Copepods as lived near the bottom, although he grants that they do not seem to correspond exactly with the deep-water varieties formerly examined by him.

not in a directly easterly direction, and that it is just the coast from the ledges of Christianssund to Stavanger which is visited by the spring herring, can I think be explained by purely meteorological reasons, among which the temperature of the sea seems to play an important part. Through the indefatigable exertions of Professor Mohn, a large number of observations on the temperature of the sea-water near our coast, taken at different seasons, and extending over many years, have been collected; and some of these observations were taken at a considerable distance from the coast. In the pamphlet published by him in French, in 1870, entitled *Température de la mer entre l'Islande, l'Ecosse et la Norwège*, these observations are given, and on the accompanying maps isothermal lines drawn for the different seasons give a very clear idea of the peculiar conditions of temperature in that portion of the sea. What immediately strikes us is the remarkable change which the isothermal lines undergo during the greater portion of the year as soon as they come nearer to the coast of Norway. Instead of running in a northeasterly direction, as before, they here suddenly bend toward the southeast, following more or less the coast.

It will also be seen that the extent of coast from the ledges of Christianssund to Stavanger, therefore the spring-herring district proper, is during winter distinguished above every other part of the coast by the remarkably uniform temperature of the sea-water. This temperature (41° F. to 43° F.) is, therefore, the very temperature which is considered most favorable to the hatching of young herring. Both these favorable conditions of temperature near the coast and the curving of the isothermal lines out in the ocean seem thus to furnish quite a natural explanation of the fact that the spring-herring, although it probably lives originally under more northern latitudes, always seeks this portion of the coast, and not, as might be expected, the one immediately north of it. From the map which shows the condition of the temperature in the middle of winter, therefore at the very time when the coming in of the spring-herrings begins, it will be seen that the herrings, in order to reach the coast near the ledges of Trondhjem, would have to pass no less than 3–4 isothermal lines, or from a temperature of 6° to one of less than 2° (43° F. to 35½° F.), while by taking a southeasterly direction they would have the same temperature (43° F.) nearly all the time. And as it is well known that the fish are very sensible of changes of temperature, we seem justified in drawing the conclusion that the migrations of the herring, both when approaching the coast and when leaving it, are chiefly governed by the temperature, and will, therefore, naturally follow the above-mentioned direction.

By this theory, which differs very much both from the older theories and from more recent ones, *e. g.*, that of Professor Nilsson, I think I am able to explain in a natural manner many hitherto entirely inexplicable phenomena in connection with the spring-herring fisheries. In order that I may not be misunderstood, I must state expressly that it is by no

means my opinion that *all* the herrings which spawn on the coasts of Northern Europe come from the above-mentioned part of the ocean. There are doubtless different tribes of herring; this seems to be especially the case in the more inclosed portions of the sea, although I am inclined to think that the number of these tribes has been greatly overrated. The northern and southern part of the Baltic has certainly each its own tribe, likewise the Kattegat, and partly the Skagerak and the North Sea. I am also of opinion that the Nordland great herring belongs to a special tribe, whose place of sojourn is farther north than that of the spring-herring, viz, in the Polar Sea. But those schools of herring which are referred to in this report which spawn on our western coast, from the ledges of Christianssund to those of Stavanger, I certainly consider as belonging to one and the same large tribe; and this opinion is confirmed by the fact that even the most experienced fishermen are not able to point out any real difference between the spring-herrings found at different points along this coast.

The chief difference between my theory and the one generally entertained in former times is this, that the various tribes of herrings are not limited in their occurrence to certain deep basins near that coast where they spawn, but that they are found all over the adjoining sea, since the herring, either singly or gathered in large and smaller schools, roam about from place to place more or less near the surface of the water in search of its food, which is the same as that which it uses when younger (as summer herring). It is evident that this leads us to the conclusion that the spring-herring is much less stationary in its mode of life than might have been supposed according to the former theory, and that many physical conditions of the sea (direction of the current, occurrence of food, temperature, &c.) exercise a very important influence on the distribution of the herrings, so that, *e. g.*, the chief mass of them will one year at a given time be found either nearer to or farther from the places where they spawn. This point is, in my opinion, of great importance, as I think I can thereby explain in a natural manner the irregularity in the spring-herring fisheries on our western coasts, which have been observed for a long time, and which have been called "herring periods." I shall have occasion to return to this point, and I will here briefly give my idea concerning the mode of life and the migrations of the herring from the time it is hatched till as fully-matured spring-herring it returns to the coast where it has first seen the light of the world, basing my views on observations made by me during this and the preceding year.

The young of the spring-herring, according to A. Boeck's observations (Om. Silden, &c., p. 14, 15), spend the first period of their existence near the bottom in those places where they have been hatched, therefore chiefly on the raised bottoms near the outer coast, where the spring-herrings generally spawn. As soon as the umbilical bag has been completely absorbed and the fins have developed, making the movements

of the fish freer and easier, it follows its instinct and goes to the surface of the water to snap at the different small animals which are found here. But as here among the outer islands it is, in its rather helpless condition, exposed to many dangers occasioned partly by physical conditions, *e. g.*, high waves, current, &c., partly by its numerous enemies, both among birds and fishes, instinct has taught it to go nearer to the coast, where it finds better protection in the less exposed bays and sounds. These young of the spring-herring are well known on our west coast by the name of "musse," and may often be seen near the coast in enormous numbers. Even when measuring only a few inches they begin to gather in schools, which constantly increase in size and which roam about from place to place, thus beginning that roving mode of life which, in my opinion, is highly characteristic of the herring; a mode of life which, in a very natural way, is occasioned by its food. The small pelagian crustaceans, which, as I think, constitute the principal food of the herring, not only in its youth, but all through its life, are very irregular in their occurrence and depend very much on the different currents near the coast. Even at a very early age, therefore, the young herrings may be found far from the places where they were hatched; and from the same reason they will very naturally, at a later period of their life, gradually distribute themselves over a comparatively large portion of the coast. It must be supposed, however, that as a general rule, at any rate during the first year, they keep near the coast where they usually find sufficient food. As the fish grow up they require more food, and in order to get it they have to go farther out into the ocean where there is greater abundance of food. Herewith those migrations begin which the young herring must sooner or later undertake to those places out in the ocean whence its ancestors, the spring-herrings, came.

If there were no disturbing elements these migrations would go on quite gradually, the herring as it grew up going out farther and farther into the open sea; and in that case we would not know anything of the often very extensive and important summer-herring fisheries, which are carried on along the greater portion of our coast and far up the deep fiords. The irregular occurrence and distribution of the small crustaceans on our coast, which is influenced by various physical conditions, changes and interrupts these migrations in many ways. These little animals are generally found in larger quantities the farther you get out into the open sea; but sudden changes of the weather and consequent changes of the currents may often drive them together in certain localities, as may during the summer months often be observed off our coasts. Wind and current may drive this dense mass of crustaceans, constantly followed by schools of herrings, toward the coast, where in the deep bays and fiords they sometimes keep the schools of herring near the land for a long time. When the crustaceans have again been scattered, or have by other currents again been driven into the sea, the herrings generally follow them. In exceptional cases, however, especially in

those fiords which run very far up into the country, it may happen that schools remain all the year round and even longer; and the herrings composing such schools will naturally assume a somewhat different appearance from the common herring or gradually form themselves into a special variety. But on the whole the occurrence of the summer-herrings near our coast must be considered as entirely transient; in other words, the summer-herring is not, as has formerly been believed, a stationary coast-fish, but, like the older herring (the spring herring), it comes from the open sea.

The correctness of this view was also fully proved by the observations which I had made this year. Some time before the large schools of herring came to Espevær, the mackerel-fishers at a distance of 6–8 Norwegian miles from the coast often caught in their nets a considerable number of large and fat summer-herring, and schools of large and small herrings were often observed from the mackerel-boats on their return toward the coast. Soon after there was a sudden change in the weather, and an unusually strong current set in toward the islands near Espevær, carrying with it enormous numbers of crustaceans which filled all the neighboring bays and sounds. These were closely followed by the herrings, first the larger and then the smaller ones. As during winter the number of crustaceans near the coast is not so large, the migration of the herrings toward the sea will be less disturbed than during summer, and there is no instance on record that spring-herrings have returned to the coast after they had spawned.

As soon as the herring has reached a certain distance from the coast and is out in the open sea it will be less apt to be enticed toward the coast by its food, as the currents farther out are generally much more regular than near the coast. Those herrings which come to our coasts in summer are, therefore, chiefly young herrings, whose migrations have not yet extended very far, and very rarely old herrings which have already spawned. I consider it quite probable, however, that among the large "merchants' herring" there are some which formerly as spring-herring have spawned near our coast.

To be brief, we can mark two phases in the migrations of the growing herring: first, a successive distribution of the young from the places where they have been hatched over a larger portion of the coast; then a migration (often interrupted during summer) toward those parts of the open sea where the old herring live. That this migration as well as the distribution of the young along the coast chiefly goes on in a northerly direction is caused not merely by the temperature of the outer sea, but also by the currents, and the decided northeasterly direction of the current which may be observed, at any rate from Stat, will furnish a very natural explanation of the fact that the summer-herring fisheries are generally richest near Trondhjem, although it is well known that the spring-herrings do not spawn anywhere near the outer coast of Trondhjem. The fat herring caught near the coasts of Nordland and

Finmarken belongs, in my opinion, to a different tribe of herrings, and holds exactly the same relation to the Nordland great herring as the summer-herring on our western coast to the spring-herring.

We now come to the difficult and so far very obscure question, "What causes the irregularities in the herring-fisheries, both as regards their location and their results, on our western coast (the so-called 'herring-periods'), which have been observed from time immemorial?" We will see whether the new views which have been advanced will in any way explain this phenomenon. We are justified in supposing that here we are not confronted by an absolutely insoluble problem, but that this phenomenon, like everything else in nature, must have its natural causes, which can be found, and as this is really the all-important question, on which everything depends, all practical and scientific investigations should be directed toward its solution. It is and always has been my opinion that this can only done from a scientific point of view. A detailed historical investigation of the fisheries may be valuable in itself, but it cannot possibly lead to any satisfactory explanation of the problem. The starting-point of the whole investigation must be a most exhaustive knowledge of the nature and mode of life of the herring, and I have therefore endeavored to arrive at all my conclusions in this way. Only if it turns out that the facts obtained in this manner can be harmonized with those gained by historical investigations, these latter will become truly valuable as corroborating the views reached by scientific investigations.

By the indefatigable zeal of the late Mr. A. Boeck, a very large number of historical data regarding the herring-fisheries on our western coast have been gathered—data which extend from the most recent time as far back as documents are extant. Most of these documents have their chief value as material for a complete history of our herring-fisheries, which he intended to publish. But there is no doubt that this great mass of documents will, among the rest, also contain information which, if used in a careful and critical manner, may form a good basis and guide for a continued scientific investigation of our herring-fisheries. Among the numerous historical data given by Mr. A. Boeck in his book, "Om Silden," I would direct special attention to the peculiar circumstance, also specially dwelt on by him, that the spring-herring fisheries on our western coast have not always commenced at the same time of the year, but that at times they have had a tendency to get later and later in the spring, which, according to Mr. Boeck, has particularly been the case toward the end of the so-called "herring-periods." The difference of time has even been as much as a month and a half, as in some years the spring-herrings have come in before New Year, while in other years fishing has not commenced till late in February. As long as the old theory was maintained, that the spring-herrings live in certain limited deep basins of the sea near that coast where they spawn, this phenomenon would be entirely inexplicable, and it would also seem

incomprehensible why the yield of the fisheries should decrease in proportion as they commenced later in spring. But if we start from the modern theory regarding the mode of life and the migrations of the spring-herring, I think it may all be explained in a very natural manner. Since, according to this theory, the spring-herrings, outside of the fishing season, are just as much as the summer-herrings dependent on the occurrence of the small crustaceans, and as this is again dependent on various meteorological conditions, especially the direction of the currents in the outer sea, it may easily be imagined that the great mass of the spring-herrings at that season of the year when they gather to go to their usual spawning-places are not always at the same distance from these places, but one year near and another year far. In the former case they will be able to reach their spawning-places in a comparatively short time, and the fisheries will therefore commence early in the season. In the latter case it will take them longer to reach the spawning-places, and the fisheries will commence later.

As it must also be supposed that roe and milt develop at a certain time of the year, and as it is certain that the herrings, like all other fish, commence to approach the spawning-places long before roe and milt are fully matured, and do not leave the coast until they have spawned, it follows that, in the first case, the spring-herrings will be able to stay longer near the coast, going farther up the bays and sounds, and that consequently the fisheries will last longer and yield a more certain result; while, in the other case, they can only stay near the shore a comparatively short time, so that it may often happen, as was the case last year, that the spawning process commences immediately after the arrival of the herrings near the coast, and that the chief mass from this cause remains at the outermost spawning-places, while only small schools are, by pollack and other fish, chased near the coast. It will thus appear that in this case the fisheries will be short and uncertain, although the same number of herrings as formerly have come near the coast. The quality of the herring will also, to a great extent, depend on the same conditions, as it is well known that the herring is better the firmer (less matured) the roe and milt are, and leaner the more the roe and milt begin to loosen. The excellent quality of the Nordland great herrings is chiefly owing to the circumstance that they are caught long before roe and milt are fully matured, as they approach the coast late in autumn, while in all probability they spawn about the same time as the spring-herring. From this early coming in of the great herring it may be concluded that they must live nearer the coast than the spring-herring; and occasional observations made by me have proved that the sea near this coast is by far richer in herring-food than the sea near our southwestern coast.

We thus arrive at the result that the irregularities of the spring-herring fisheries on our western coast must be traced to meteorological causes in the outer sea, and this not so much during the fishing season

as during the rest of the year. As far as I know, it has not yet been shown that there is any regular periodicty (thus causing certain regular herring-periods) in these causes (wind, current, and temperature). Meteorologists will have to decide in how far this may be possible. It is a fact that there is considerable difference in the occurrence of the "herring-food" near our western coasts in summer between one year and the other. Some years the sea near the coast has all through summer been filled with an enormous quantity of various small marine animals, while in other years they have almost entirely disappeared, or have only accidentally been driven near the coast by the current, quickly to disappear again. The most peculiar feature of this "herring-food" is the great quantity of very remarkable little animals which from the earliest times have attracted the attention of the fishermen. These are the so-called "Salper" (Salpæ), little animals which are as transparent as glass and float freely about in the sea, either singly or connected into long chains resembling strings of pearls. They are genuine pelagian animals which every year are found in large numbers far out in the open sea, but whose occurrence near the coast is very irregular. Years may pass without a single one of these animals showing itself near the coast, till suddenly one year they come in in such enormous numbers that every bay and sound is filled with them. It is scarcely probable that the herrings feed on these animals, but they are invariably accompanied by a large number of other small pelagian animals, with which they come from the ocean, and of these the "herring-food" proper (small crustaceans) forms by far the largest part. If such enormous masses of "herring-food" fill the bays and sounds during summer, it may be supposed, from what has been said before regarding this food, that those portions of the sea which are immediately outside the coast must contain a great number of the same animals, and that there likewise must be a considerable number of such animals as feed on these crustaceans.

According to my theory, I therefore also suppose that the spring-herrings in such years are nearer the coast than in years when the quantity of "herring-food" in the coast-waters is not so great; and I am inclined to assign greater importance than is generally done to this circumstance which from time immemorial has been considered as one of the "signs" which indicate good spring-herring fisheries during the winter. I am likewise inclined to ascribe similar causes to the decline of the formerly so productive Bohuslän fisheries. At a time when owing to peculiar currents in the sea an unusual quantity of "herring-food" has filled the North Sea and the Skagerak, it may well be supposed that a portion of the great mass of herrings coming originally from the northwest may have gotten so far into this part of the sea that when the spawning season approached they, in following their usual southeasterly direction, would come near the Bohuslän coast, where they spawned, returning to this same coast in accordance with the innate instinct of all fish; and that in this way they have developed into a tribe of herrings

peculiar to the Skagerak, whose disappearance at a later time may in part at least have been caused by a decrease of "herring-food" in these waters.

There is another feature of the recent spring-herring fisheries which I cannot pass by, as it seems quite inexplicable and has been the subject of much unnecessarily anxious thought. It has been maintained that during the last few years a new kind of inferior herring has made its appearance in the spring-herring district, a kind of herring which has been unknown in former years; and people have considered this as a certain sign that the spring-herring fisheries would soon come to an end. This supposed new kind of herring is the so-called "mixed herring," which especially last winter, in January and February, and in some cases even earlier, has at various points appeared in considerable numbers even outside the herring district proper, among the rest at the mouth of the Korsfiord. Unfortunately I had no opportunity of personally examining these herrings, and the inquiries made of the fishermen have not given me a very clear idea in what respects they differed from other herrings. All seem agreed, however, that they are not the common spring-herrings. But as for the rest the accounts differ very much. Some say that they are of an excellent quality, others that they are lean; some say that they have roe and milt like other spring-herrings, while others maintain that they have neither. Their size is also given very different. The fact of the matter is, that the "mixed herring," as its name indicates, shows great differences, so that among them one may find fat and lean, large and small fish, some with roe and milt, and some without. How can the occurrence of these herrings be explained? There must be a possibility of answering this question satisfactorily, thus removing the darkness which has hitherto enveloped it.

Although I have not personally examined these herrings, I think I am able to give an explanation; and it is again the before-mentioned new theory regarding the mode of life and the migrations of the spring-herring which will materially aid us in solving the problem. The greatly differing accounts as to the appearance of these so-called mixed herrings impressed me very strongly with the idea that they are herrings of different ages, and that only a comparatively small number of them are fit for spawning, as with most of them roe and milt are either not yet fully matured, or are entirely wanting as is the case with the so-called "straal" herring or "blood" herring. As these herrings can therefore not possibly come near the coast for the purpose of spawning, and as they cannot come in search of "herring-food," of which at this time of the year but little is found near the coast, it must be supposed that from some reason or other they are against their wish forced to approach the coast.

From the information which I was able to obtain regarding this so-called "mixed herring", and judging from the time when it first makes its appearance near the coast, I have come to the conclusion that their

coming near the coast is owing to the same cause which brings the so-called "straal" or "sun-head" herrings just previous to the spring-herring fisheries, or the coming in of the so-called "spring-herring mountains." I likewise think that I can in a quite natural manner explain why these herrings which are chased toward the coast, as has been described in another place, have of late years appeared in unusually large numbers and have been so mixed. It is my opinion that the chief mass of the spring-herrings, from reasons which have been given before, have of late years lived at an unusually great distance from the spawning-places, so that the great masses of herrings which approached the coast had to pass a considerably larger portion of the sea than is generally the case. The scattered schools of herrings which in accordance with my theory must be supposed to consist chiefly of young fish which are not yet fit to spawn, fish which have not yet been very far out at sea, are now by the irresistible advance of the great masses of herrings toward the coast forced to give way, and are thus compelled to seek the coast, exactly as is the case with the so-called "straal" herring. Regarding this last-mentioned kind of herring A. Boeck has in his work (p. 24) expressed a view which seems highly probable, viz, that "they are possibly stragglers from the spring-herring schools of the preceding year, which having less access to food, have not taken food enough to complete the development of their generative organs." A. Boeck likewise supposes that in all probability these herrings generally live at a comparatively short distance from the coast, which would also explain their coming immediately before the coming in of the spring-herrings, while the "mixed herrings" must be supposed to come from a greater distance from the open sea. I therefore think that the so-called "mixed herrings" are composed of very different elements, partly barren herrings ("straw-herrings"), young herrings which have not yet become fit for spawning (these would have been called "summer-herring" earlier in the year), and some stragglers from the great mass of spring-herrings.

I have thus, as I think, in a natural manner endeavored to explain some of the most important, and at the same time darkest, points in the spring-herring fisheries. Although the theory I have advanced, with the conclusions deduced from it, as well as the explanation of the different phenomena, cannot be said to have been so firmly established in all its details that no possible opposition could be raised to it, it is nevertheless, as we have seen, essentially based on actual observations, and can therefore not be termed "mere philosophizing." As I consider it of the greatest importance to throw some light on these dark problems, I have considered it my duty to express my views quite freely, although I certainly wish that they could have been based on a larger number of actual observations. The field which the salt-water fisheries offer for practical and scientific investigations has been so little explored that we cannot expect to deal exclusively with incontrovertible facts. We would not get very far in this way. It is absolutely neces-

sary, every now and then, to go beyond these facts, or rather with these facts as a basis, to form a distinct idea regarding the causes of the many different phenomena and their mutual connection. This can only be done by forming some theory, and I therefore consider this as necessary if the investigations shall be carried on after a definite plan and in a rational manner.

If, in conclusion, some one should ask me what I think as to the results of the fisheries in coming years; in other words, in how far the spring-herring fisheries will in the future be a success or a failure, as has been the case during the last few years, I must first of all solemnly declare that I never thought I was a prophet, nor intended to pass myself off for a prophet. I consider it necessary to say this, as I learned to my sorrow that many people in reading my former report entirely misunderstood me, as if I had promised that in the following year there would be rich spring-herring fisheries. No such thought entered my mind, especially as there are many unforeseen circumstances which during the fishing season itself may exercise a hurtful influence on the fisheries, even if the mass of herrings should be ever so large. Some of my utterances regarding the spring-herring fisheries may not have been couched in as cautious or conditional language as they should have been, considering how many people are interested in or dependent on these fisheries. The reason of this must be found in the fact that my investigations in the southern herring district revealed a condition of affairs entirely different from what I had expected. I had gone there with the preconceived notion that we were near the end of a "herring period," or near the end of the entire spring-herring fisheries; and I consequently expected to find some signs of this, which I thought must show themselves at this season of the year. To my greatest astonishment, I found no such signs whatever; the young fish were, as always, in their usual places in large numbers, and all accounts agreed that also this year enormous masses of herrings had approached the coast, although they had not come as near as in former years. This, in connection with the fact, proved by my observation of the summer-herring, that this herring was the same as the spring-herring, only at a different age, of course convinced me that there was no decrease in that tribe of herrings which according to the popular notion lived in the deep immediately outside the coast.

As with these facts before me I could not think of any other probable cause why the spring-herring fisheries should come to an end but a decrease or degeneration of the respective tribe of spring-herrings occasioned by some unknown causes, and as I in my capacity as a naturalist could not possibly rest satisfied with the explanation that the spring-herring fisheries would come to an end, because this had been the case many years ago under circumstances which showed some similarity with what had been seen or what people believed they saw during the last few years, I could not possibly entertain the idea that

there were any distinct signs indicating a speedy end of the spring-herring fisheries. I consequently expressed my views perhaps with too great freedom, saying that I had found nothing which would prevent the spring-herring fisheries from being successful in the future in their usual places; and I would direct attention to the fact that this is very different from making a distinct promise that next year there would be rich spring-herring fisheries. My views are the same now as then, viz, that for the present there is no reasonable cause whatever to suppose that the spring-herring fisheries on our western coast will come to an end, although their yield may, through many accidental causes, vary from year to year, just as has been the case in former times.

VI.—REPORTS MADE TO THE DEPARTMENT OF THE INTERIOR OF INVESTIGATIONS OF THE SALT-WATER FISHERIES OF NORWAY DURING THE YEARS 1874-1877.*

By Prof. G. O. SARS.

I.

REPORT FOR 1874.

As there is an item in the appropriation bill for next year for the practical and scientific investigations of the fisheries, I shall give a brief report of the observations made by me this year, and I shall also give my opinion as to how they should be continued.

As I mentioned in a former report to the department, it was my original intention this year to investigate the fisheries in Finmarken. It was my opinion that these investigations should be made chiefly in the months of March, April, and May; but as Professor Rasch had sent in his resignation in the beginning of the year I had to abandon this plan, since my office as assistant professor of zoölogy obliged me as long as the professorship was vacant to attend to its duties, lectures, and examinations, which could not be taken by any one else. I had thus no time at my command before the beginning of the midsummer vacation, *i. e.*, the end of June. But as already the year before reports had been made to the department by the governor of Finmarken by fishermen and several gentlemen interested in the fisheries, all expressing the fear that the whale fisheries, which during the last years had been carried on in the Varanger fiord by S. Foyn, might exercise a hurtful influence on the other fisheries, and since the department had at the same time been requested to have this matter investigated as soon as possible by a competent scientist, I thought that I must adhere to my original plan and make my investigations this year in Finmarken. It is true that the general fisheries had closed everywhere by the time I could leave my duties at the university, but on the other hand it was the most convenient season for investigating Foyn's whale fisheries, as they are chiefly carried on during the months of July and August. As I moreover expected to make some preliminary observations on the general fisheries, which I considered necessary before the direct investigations could be commenced, I concluded to proceed to Finmarken, even if I should get there at a time when no important fisheries were carried on.

* Indberetninger til Departmentet for det Indre fra Professor Dr. G. O. Sars om de af ham i Aarene 1874-1877 anstillede Undersögelser vedkommende Saltvandsfiskerierne. Christiania, 1878. *Translated by Herman Jacobson.*

As soon as I had finished my examination work and had gotten the necessary apparatus I started for the North and arrived at Vardö on the 15th of July. After a stay of eight days, which I chiefly spent in gathering information regarding the fisheries which had just come to an end, and in investigating the physical conditions of those localities where the fisheries are principally carried on, I went to Vadsö, where I staid three weeks. Here I had every opportunity to study Foyn's whale fisheries, which just then were in very successful operation. Nearly every day I could examine whales which had been caught by him, and several times I had a chance of witnessing the way in which these fisheries are carried on.

The result at which I arrived regarding the influence which the whale fisheries may have on the other fisheries coincides exactly with my opinion which I had formerly expressed to the department. It is my firm conviction, now as then, that no danger whatsoever need be apprehended from the whale fisheries. I have in a former report to the department given my reasons for this view, and now, after having personally examined the matter, I can add a fact which proves still more fully that the complaints made against Foyn's fisheries are entirely unfounded. The kind of whale which Foyn catches almost exclusively, the so-called blue whale (*Balænoptera Sibbaldii*), has in all probability nothing whatever to do with the other fish. Repeated investigations of the contents of its stomach have convinced me that its food consists almost exclusively of a small transparent shrimp (*Thysanopoda inermis*), which by the inhabitants of this coast is called "kril." Although there was no lack of herrings of different sizes during the time I staid in the Varanger fiord, I never found the slightest trace of herrings in the stomach of the blue whales, and Foyn himself has assured me that he never had found any herring in the whale. The whale which is mostly found here is of a much smaller kind (probably *Balænoptera laticeps*), a whale which Foyn does not care for at all, because it is neither as large nor as fat as the blue whale. Besides this whale two other kinds of whale come here during the herring fisheries (so I have at least been informed), viz, the *Balænoptera musculus* and the *Megaptera boops*, but both of them in smaller numbers. All these three kinds of whales seem to leave the coast when the herring fisheries have come to an end and follow the herring to the ocean; while the blue whale only begins to approach the coast in any considerable number after the herring fisheries, in order to feed on the enormous masses of "kril," which at this time are by the current driven toward the coast, especially in the Varanger fiord. Even those who still hold to the old opinion, that the whales chase the herrings toward the coast, will thus have no reasonable cause for anxiety, as Foyn does not catch the so-called herring-whale, but chiefly a different kind which comes near the coast at a later season of the year.

Besides these investigations (concerning Foyn's whale fisheries) I

made during my stay at Vadsö a number of zoölogical and physical observations in the Varanger fiord, which will prove very useful when, as I hope, I shall have an opportunity to stay here during the herring fisheries, which, however, it would lead us too far to give here in detail. From Vadsö I returned to Vardö, in order to make some observations which want of the necessary apparatus had prevented me from making during my first stay. After having thus studied to some extent the condition of things in the eastern portion of the herring district, I desired for comparison's sake to examine one or more points in the western portion of this district, and, after a sojourn at Vardö, I went west to Hammerfest, where I intended to begin my observations. I found, however, that this place was less convenient for such observations, and I therefore took the first steamer and went to the next stopping place, Hasvig, at the southwest point of the island of Sörö, an old and well-known fishing station, which forms the western boundary of the herring district.

My observations at this point, which I found very convenient in every respect, yielded several interesting results; the observations of the temperature of the sea-water at different depths, which I made here, were of special interest to me in comparing them with the observations which I had made in the eastern district. Here, my attention was also first directed to some physical conditions which I consider very important.

I had now, by the observations which I had made at the four points mentioned, obtained a tolerably correct idea of the condition of things in the whole herring district; and besides this, I had endeavored to get all the possible information regarding the herring and the cod fisheries dependent thereon, which I considered necessary as a basis of future direct investigations of these fisheries. Thus far, I had therefore accomplished the object of this journey.

Besides the cod-fisheries, however, another important fishery is carried on in our northern coasts, which, especially of late years, had made a most remarkable progress, and to which my attention was naturally directed, all the more as the conditions under which this fishery is carried on are to a great extent still enveloped in darkness. I here refer to the great herring or sea-herring fisheries. I was therefore anxious to gather during this journey all possible information regarding this fishery, especially as it seems that during the last few years remarkable movements are going on among the herring masses, which seem to take them farther north than has formerly been the case. It is well known that formerly the great herring fisheries as a general rule commenced at Langenaes in Vesteraalen, and have then gradually gone south along the coast of Helgeland. Last year (and probably this year too) the great herrings made their appearance very early and much farther north, considerable numbers coming even as far as East Finmarken, while the fisheries did not extend much farther south than Bodö. This seems to

indicate a change in the line of travel of the great herring masses, and it will be of great interest to find the cause of this. I was very anxious to examine various points in the great-herring district, but as my vacation had almost come to an end, I could only devote about a week to it.

Several reasons determined me to select Bodö as my place of observation. Last winter the great herrings had come here in unusually large numbers, and as this was about the southernmost point where any considerable fisheries are carried on, I hoped to obtain here more light regarding the dark problem of the spawning of the great herring, and in case spawning had been going on, to make a thorough investigation of this whole locality. But here, as everywhere else, I was told that the great herring does not spawn at all when near the coast. Only in one solitary case had spawning—a phenomenon which even the most inexperienced fisherman can understand—been observed in a bay near Landegade where a school of herrings had remained an unusually long time, till the end of January. Here the herrings are said to have actually spawned. But at that time the great-herring schools had long since left the coast. The remarkably stormy weather which prevailed during my stay at Bodö unfortunately prevented me from examining that point, and the same cause prevented me from making other observations, as had been my original intention.

The information regarding the great herring which I gathered during my journey in connection with observations of the physical conditions of our northern coast, has to a certain extent modified my views regarding the migrations of the herring, and has suggested to me the idea of a more intimate connection between the great-herring fisheries and the spring-herring fisheries on our western coast, than I had formerly considered possible. I shall, however, defer giving my views until, as I hope, I shall have an opportunity to witness the great-herring fisheries in person, and on the spot make those observations which I consider necessary for giving weight to my views. I believe I have found, at least, a partial cause of the remarkable change in the migrations of the great herring which have taken place during the last few years in the peculiar physical conditions of the outer sea. I shall here only draw attention to some points which I consider important. I was there told by members of the Austrian Polar Expedition whom I had the good fortune to meet, that during this and partly during the preceding year the condition of the Northern Polar Sea had been exceedingly favorable, as the sea had been more open than had ever been the case before.

During my stay at Hasvig I learned to know another circumstance which probably is intimately connected therewith. During this year an unusual quantity of driftwood began to show itself on the west coast of the island of Sörö, chiefly composed of a species of spruce which is not found in our country. Such a thing has not occurred for many years; but some of the oldest inhabitants say that such driftwood had come to this coast a long time ago. This seems to point distinctly to peculiar

changes in the current of the sea which certainly must have some influence on the distribution of the herrings (compare my last report and the new theory there advanced by me concerning the places of sojourn and the migrations of the herring). So far, however, the data which I have gathered are not sufficient to base on them any positive opinion regarding the great herring. I consider these data, however, as significant hints, and have no doubt that continued investigations will bring to light more facts of a similar character which will finally solve the dark problem of the migrations of the herring and some of our other fish.

II.

REPORT FOR 1875.

It was my intention during this journey—

a, to investigate the *mackerel-fisheries*, in order to ascertain the conditions under which these fish come near our coasts;

b, to investigate the *lobster-fisheries*, chiefly with a view of obtaining a firm scientific basis for settling the vexed question as to the best way of protecting the lobster; finally,

c, to ascertain in how far the government would be justified in taking steps with regard to the memorial from the governor of Sarlsberg and Laurvig, advocating certain *limitations in the use of the drag-net* for that portion of the coast extending from Nevlunghavn to the Tonsbergfiord.

I started on the 19th of June, and was absent from home till the 19th of August, therefore altogether two months. During this time I visited the following places: Lurhavn, Tananger, Hvitingsö, Skudesnaes, Akrehavn, Flekkerö, Langesund, Nevlunghavn, Fredriksvaern, Kjaerringvig, Sandefiord, Bogen. I made observations at all the places, in the six first-mentioned chiefly regarding the mackerel and lobster fisheries, and in the six last-mentioned ones likewise regarding the cod-fisheries.

I have the honor herewith to submit the results of these investigations to the department.

I shall divide my report into three chapters:

a. On the mackerel-fisheries.

b. On the lobster-fisheries.

c. On dragnet-fishing on the coast from Nevlunghavn to Tönsbergfiord.

1.—MACKEREL FISHERIES ON OUR SOUTHERN AND WESTERN COAST.

These fisheries have only become important of late years, since people have commenced to pack mackerel in ice and export them to England. At present these fisheries are, next to the herring and cod fisheries, the most important of our salt-water fisheries. They are carried on not

merely along our whole southern coast, but likewise on the western coast, at least as far as the heights of Bergen, and during the summer give employment to a large number of fishermen, who during a favorable season make a right good living. These fisheries are at present chiefly carried on by means of floating nets from May till the middle of July, and generally at a considerable distance from the coast, sometimes 6–8 (Norwegian) miles.

As has been the case with several of our well-known fish, many erroneous notions have likewise prevailed with regard to the nature and the migrations of the mackerel. Some of these notions are even entertained at the present day, and are brought forward in ichthyological works. Although it is of course impossible for me, after having studied the nature of the mackerel only for a comparatively short time, to pronounce a definite opinion on every point in its natural history, I nevertheless feel competent to correct some of the erroneous notions which have been entertained hitherto, and through direct observations to supplement our knowledge of this fish.

The first question which presents itself is this: "Where is the proper home of the mackerel?" It is well known that the grown mackerel like the spring herring and the codfish only visits our coasts during a certain season of the year, and then disappears without leaving the slightest clew as to its whereabouts. Where does it go, and where does it stay during the remaining portion of the year? The opinion which at present is most prevalent among zoölogists is, that the mackerel stay in the great depths immediately outside the coast, an opinion which has also been advanced with regard to the spring herring, but which—in my report for 1873—I have endeavored to prove is erroneous.

As far as the mackerel is concerned another erroneous opinion is very widely spread, viz, that while living in the deep it is blind and lies at the bottom in a sort of torpor. Although this is highly improbable, we still find it mentioned in many ichthyological works; and so far, at least, this opinion has not been seriously refuted anywhere. The fishermen, who of course were the first to advance this opinion, are thoroughly convinced of its correctness. They say that experience has taught them to believe it. They maintain that in the beginning of the fisheries the mackerel enters the nets much easier than later in the season; and this, they say, can only be explained by the circumstance that the mackerel cannot see very well, while later when it has got its full sight, it is more cautious. They say that any one can see the opaque skin which covers the eyes of the mackerel, and that its disappearance and growth may be observed during the summer. With the first mackerel which are caught early in spring, this skin covers the greater portion of the eye, with the exception of the middle portion. Later in summer the skin becomes more transparent and recedes from the middle of the eye; while toward fall when the mackerel is about to return to the deep, it begins to grow and become more opaque.

All this is certainly correct, but it is a very rash conclusion to suppose that this skin ever covers the whole eye, so that in the end the fish becomes entirely blind. With a view of ascertaining the truth in this matter I have examined mackerel both in the beginning of the fisheries and later in the season, and it is my firm conviction that the mackerel can see as well early in the year as later, although the above-mentioned skin decreases in size toward summer. This skin is nothing else but two folds of skin, which are also found in other fish (*e. g.* the herring), and which from both sides extend over the eyeball. These folds never reach over the pupil of the eye, which, as is well known, is the only channel through which rays of light can enter the eye. The faculty of seeing would, therefore, not be affected in the least, whether these folds are transparent or opaqne, whether they cover a larger or a smaller portion of the opaque parts of the eye. The greater development and smaller degree of opaqueness of these folds earlier and later in the year are simply occasioned by the mackerel's being fatter at that time. In the middle of summer immediately after spawning the mackerel is thinnest, and that fat which formerly was found in the above-mentioned folds has therefore been absorbed, which of course has an influence on their extent and transparency. A completely blind mackerel has never been seen yet, and will never be seen; and still it is by no means rare to catch stragglers late in autumn and winter, or at that time when, according to popular opinion, the mackerel ought to have lost its sight long since.

As long as it was supposed that the mackerel was blind in winter and lay in a sort of torpor, it followed necessarily that it must keep on the bottom. But as this, as I believe, is not only improbable, but an absolutely foolish notion, we must again discuss the question regarding the supposed place of sojourn of the mackerel when it is not near the coast. The oldest supposition, given up long since (Andersson's), is, that the mackerel came from the sea near the North Pole, and that from here at certain seasons of the year a large school travels south, like a swarm of bees leaving its hive. This school was then supposed to pass through the Polar Sea and the Atlantic Sea like a dense phalanx, and having reached the heights of Europe to divide into smaller schools, each of which sought a special part of the coast, to return by the same route and spend the rest of the year in undisturbed repose under the ice of the Polar Sea. Andersson's migration theory, which was applied not only to the mackerel but also to the herring, has recently given way to an entirely opposite theory, viz, that the mackerel is a stationary fish having its winter quarters in the deep places immediately outside that portion of the coast where later in the season it comes to spawn. This theory is in my opinion just as erroneous as the other. I have in other places given my theory regarding the herring, according to which I suppose that this fish leads a pelagian or roving life all the year round, and is found in smaller or larger schools in different places in the outer sea wherever it finds most food.

As far as the mackerel is concerned I do not doubt for a moment that it is a genuine pelagian fish. Its whole build and its looks indicate this, its slender form, its compressed, wedge-shaped head, its small fins, its powerful muscles, its shining sides, glittering like silver and gold, and the beautiful sea-blue and sea-green shading of the back. All genuine bottom-fish have a plump and compressed body, a flat head, large fins, and generally gray, white, or black colors, or a mixture of the three, but very rarely any brilliant colors. Any one who is acquainted with the sea on our southern and western coasts knows the playful nature of the mackerel when near the land, how they gambol about on the surface of the water, so it resembles a seething caldron; how, in a stiff breeze, it races with the swiftest sail-boat. All this is by no means in keeping with the character of a bottom-fish. It seems improbable in the highest degree that during the rest of the year the mackerel should suddenly change its nature and lead a melancholy life down at the bottom of the ocean. The mackerel has got its elegant and well-proportioned body, in order to move quickly about in the water, and there are very few fish which excel it in this. It is therefore also well adapted for long journeys, and, although I do not approve of Andersson's migration theory, I incline to the opinion that the mackerel which every summer come to our southern and western coasts in large schools, come from a great distance. If we examine the geographical distribution of the mackerel on the coasts of Europe, we find that it is very different from that of the herring. While the herring is only found on the northern coasts from the Channel to the northernmost boundaries of our continent, the mackerel is found much farther south. It is not found in any very large numbers on the heights of Söndmöre, while farther south it is found more frequently. Besides our southern and western coasts, it is found on all the other coasts of the North Sea, viz, in Denmark, Germany, Holland, and England, also on the Atlantic coast of Scotland and England, near Ireland, in the Channel, on the coasts of France, Spain, and Portugal, and in the Mediterranean as far as the Black Sea; and it is even said to have been found as far south as the Canary Islands. It is also found on the eastern coast of North America.

We see from this that it is a much more southern fish than the herring. Its proper home is, in my opinion, the Atlantic Ocean along the whole western coast of Europe from the Orkney Islands and the north coast of Scotland to the Mediterranean, while the home of the herring is chiefly the Atlantic Ocean north of Scotland, and the Polar Sea. Its mode of life while out in the open sea is unfortunately but little known. I have been told, however, that grown mackerel are at different seasons of the year occasionally caught by sailors off the coast of France and Portugal. In all probability they live more scattered here than when they are near the coast, perhaps, also, at different depths under the surface, but never on the bottom. It is not improbable that some of those mackerel which come to our coasts do not leave the North Sea. I incline, however, to

the opinion that these can only be a very small portion of the enormous masses which come to the coasts of the North Sea. I have good reason to suppose that the greater portion come from a greater distance, viz, from the Atlantic Ocean, chiefly by way of the Channel, and some along the northern coast of Scotland. The largest mackerel fisheries are carried on in the Channel, and several things seem to indicate that the mackerel which are caught on the coast of Holland belong to the same schools which have entered the Channel from the Atlantic. At the end of July and the beginning of August, the very time when our mackerel fisheries have closed, mackerel are, according to Lowe (*Fauna Orcadensis*), seen in large schools near the Orkney Islands. These are, probably, schools returning from the coast.

The next question to be answered is: "What are the conditions of the regular visits which the mackerel pays to our coasts?" It is a fact which should have been known long since, that the same phenomenon which, at other seasons of the year, causes the coming of the spring-herring and the codfish, viz, the spawning process, brings the mackerel to our coast. Zoölogists have hitherto had no idea regarding the peculiar circumstances under which this spawning process is going on, no idea where the mackerel drops its roe, whether in shallow or deep places, nor have they known anything concerning the development and further growth of the mackerel. All these important points in the natural history of the mackerel have remained in the dark up to the present day, and this in spite of the mackerel's being one of the most common fish in Europe. The cause of it is this, that ichthyologists have formerly taken too little pains to study the mode of life of the different fish while in the water, and have confined their investigations to the specimens preserved in museums, or, at best, to dead fish which they had obtained from some fisherman. In this way exact descriptions of fish may be written, and diagnostic data given serving to separate one species from the other, but all that important part of the natural history of fish, comprising their mode of life, their migrations, spawning, and development, will remain in the dark. On these important points nearly all information has been obtained from fishermen and other persons utterly ignorant of zoölogy, and numberless erroneous ideas have consequently been advanced.

The first preliminary investigations of the spawning of the mackerel were made by me during one of my zoölogical tours, in the summer of 1865. During the journey I made this summer I had an opportunity to supplement and corroborate my former observations. The mackerel spawns on the surface of the water, sometimes near and at other times far from the coast, without regard to the depth and the nature of the bottom. The roe does not sink to the bottom as is the case with the roe of the herring, but floats near the surface and there goes through all the stages of its development. In this respect the mackerel resembles closely the codfish and some other salt-water fish whose spawning

process I observed several years ago. In the beginning of July the roe of the mackerel begins to loosen, and about the middle of July most of them have done spawning. The spawning period may, therefore, as a general rule, be placed about the first half of July. By gently pressing the sides of mackerel caught during this time, mature roe may be procured for investigations. It comes out of the genital opening of the mackerel in the shape of small beads, clear as crystal, which when placed in a vessel containing sea-water keep floating near the surface as long as the roe is fresh. The grains of roe or the eggs are of about the same size as those of the codfish (or a little larger), but are distinguished from these, as a closer examination will show, by a large and very distinct and clear oil-bladder near the upper pole (that side of the egg which is uppermost). By this peculiar oil-bladder, which is invariably found in every egg, the roe of the mackerel can easily be distinguished from that of most other fish. Impregnated and developed roe may be obtained in a very simple manner by dragging a fine net along the surface of the water, especially during westerly or southerly wind when the current goes toward the coast. I have in this manner obtained as much as I desired, and have been enabled to follow its whole development, which, in all essential points, agrees entirely with what on former occasions I have stated concerning the development of the roe of the cod. I also succeeded in hatching young fish from roe obtained in the above-described manner, but was not able to keep them alive for any length of time. When coming out of the egg they are comparatively less developed than the young codfish, entirely transparent and clear as water with the exception of a little sulphur-colored spot on each side of the neck. Mackerel which have been recently hatched may easily be recognized, not only by these spots, but also by the same bright oil-bladder which characterized the individual grains of roe. This oil-bladder, which formerly occupied the top part of the egg, is now inclosed in the back part of the belly in the residue of yolky matter.

I was unfortunately prevented from following up the further development of the young mackerel. This summer was very unfavorable to such observations, as the mackerel spawned at an unusually great distance from the coast, and as a constant land-wind drove the roe and the young fish far out into the sea. Both this year, however, and on former occasions, I have about the same time or somewhat later observed small mackerel, measuring about a finger's length, on the surface of the water and invariably at a considerable distance from the coast. These young mackerel, which had already assumed the definite shape and color peculiar to the mackerel, are doubtless one-year-old fish. In the Christiania fish-market one may see large quantities of these one-year-old mackerel, every year somewhat later in the season; and besides these a somewhat larger kind, the so-called "spir" or small mackerel, about the size of a common herring, which must therefore be about two years old. When a mackerel is three years old I consider it capable of spawn-

ing. Like all pelagian fish, it then goes out to sea, while during the first two years of its life it roams about in the neighborhood of the coast.

Immediately prior to and during the spawning process the mackerel are generally very restless and roam about in dense schools (males and females together) in different directions near the coast and so near the surface that they can be seen from quite a distance by the curly appearance of the water. The schools always go against the stream and are liveliest when a fresh breeze is blowing. The natural cause why the mackerel enters the nets easier at this season than later is this, that it is completely taken up by the spawning process, and by no means defective sight. When the spawning process is finished, the schools begin to scatter and gradually go out to sea again. The fish will then not enter the net so readily, although they will bite a baited hook, because they have scarcely taken any food during spawning, and are, consequently, very hungry.

Concerning the general mode of life of the mackerel many incredible things have been said. One of these fabulous reports is this, that mackerel, like sharks, attack men swimming or bathing in the water, and that if their number is very large they will overcome even the strongest man. The improbability of this report, which is very generally believed, is self-evident. A close examination of the mackerel will convince any one that it cannot possibly hurt a man. Its jaws are too weak and its teeth too fine. To smaller fish and marine animals, however, it may certainly prove a dangerous enemy. I have several times observed the greedy manner in which mackerel scarcely a finger long have chased young herring and decimated their schools. It will be seen from this that the grown mackerel must be a very dangerous enemy to the young herring; and personal observations have convinced me that this is really the case. On this circumstance the so-called autumn-mackerel fisheries are based, which are carried on in the deep fiords long after the time when the great mass of mackerel have left the coast. The so-called autumn-mackerel are schools which have separated from the chief school, which instead of going out to sea have commenced to chase the small herring and followed them into the deep fiords where they remain as long as they find sufficient food. The fatness of the autumn-mackerel is caused by its rich food, generally consisting of small herring, but also of other small pelagian animals. As soon as this food begins to get scarce the mackerel gradually disappear and go out to sea again, and toward winter it is merely accidental if mackerel are caught on hooks with other fish. That the autumn-mackerel later in autumn generally goes deeper than the summer-mackerel, is easily explained by the circumstance that there is so much fresh water near the surface in our fiords, and likewise by the change in the temperature of the surface-water. But the mackerel will never be found constantly near the bottom like flounders and other bottom-fish, but always some distance from it.

From all that has been said concerning the propagating of the mackerel, it will be self-evident that there is no danger whatever of destroying their spawning-places by too extensive fishing, as has often been maintained with regard to the herring-fisheries. Nor do I believe that the floating-net fisheries carried on in the open sea near our southern and western coasts can have any marked influence on the number or migrations of the mackerel. If, therefore, a decided decrease has been noticed in the mackerel-fisheries on our southern and western coasts, the cause of this must not be sought in the manner in which nor in the extent to which the fisheries have been carried on, but rather in the peculiar physical conditions of the open sea, which have induced the great mass of mackerel of late years to spawn at a greater distance from the coast than usual. It is well known that a similar phenomenon has for quite a number of years been observed in the spring-herring fisheries. This similarity between the two fisheries is certainly not purely accidental. In my opinion the herring and the mackerel agree in their pelagian mode of life, and the migrations of both these fish must therefore be dependent on analogous conditions of the open sea; although the distribution of the herring and the mackerel throughout the sea is essentially different, I consider it as certain that the changed physical conditions which must be supposed to have exercised their influence on the kind of fish found in one basin of the sea, cannot have remained entirely without influence on the portion of the sea close to it where the other kind of fish were living.

2.—THE LOBSTER AND THE LOBSTER-FISHERIES ON OUR SOUTHERN AND WESTERN COASTS.

Like the mackerel-fisheries, the lobster-fisheries on our coasts have, of late years, become very important, which may be seen from the large number of lobsters which are annually exported to England, not counting those which are consumed at home and exported to other countries, especially to Denmark. At present, the lobster-fisheries are carried on with varying success along our whole southern coast and along a great portion of our western coast. The northernmost point where I have observed lobsters is the Loffoden, where some years ago I had occasion to examine a recently-caught young lobster which was brought to me as an animal entirely unknown in these regions, and regarded with much curiosity by the inhabitants.

Lobsters are almost exclusively caught in traps made of wicker-work ("lobster-baskets"), which are set at a depth of 1 to 5 fathoms and baited with small fish. As these fishing-implements are, comparatively speaking, cheap and easily worked, so that even infirm and aged people can attend to them from a small boat, these fisheries are of great importance to the poorer portion of our coast population. And as the

exportation of lobsters to foreign countries (especially to England) brings considerable sums of money into the country every year, the government has long since taken steps to prevent the destruction of this important source of income by making regulations for the better protection of the lobster. The views regarding the time and extent of these regulations have been very different, and of late years memorials have been presented to the government from various places asking for a change in the existing lobster-laws. But, unfortunately, very little has been done so far. In order to judge in this matter it is absolutely necessary to have as complete a knowledge as possible of the natural history of the lobster. But in this respect very little progress has been made. Although the lobster belongs to the commonest marine animals on the coast of Europe, and has been made the subject of special investigations by many naturalists, its mode of life is still enveloped in darkness. Even some of the most important points in its natural history have till quite recently been entirely unknown. I have already on former occasions endeavored to throw light on one of these points which, in my opinion, deserves special attention, viz, the propagation and development of the lobster (see "*Vid. Selskabets Forhandlinger*" for 1874—Transactions of the Academy of Sciences). It was my intention on the present journey to observe other points in the natural history of the lobster, and gather all the information which might throw light on them; I consequently staid for some time at several places on our southern and western coast where lobster-fisheries are carried on, among the rest, Tananger. Although I must confess that the results of these investigations did not come up to my expectations, I, nevertheless, will briefly report my experience, chiefly with a view of gaining a basis for my opinion regarding the protection of the lobster and the best time for it.

As to its organization and its analogy with similar crustaceans, the lobster must doubtless be on the whole considered as a stationary animal. It never undertakes long migrations like some of our fish. The lobster certainly moves about with great swiftness and ease aided by its strong tail and the swimming apparatus attached to it; but this mode of moving about is evidently not the rule. The hard-shell and ponderous lobster must always make an extra exertion in moving about, and its movements can therefore not be of long duration. People certainly talk of the so-called "traveling lobsters" ("*Færd-hummer*") which are said to come from the open sea in large schools; and some even say that they have seen such schools many miles from the coast moving about rapidly near the surface of the sea. If this is really so, I consider it as absolutely certain that these schools come from no very great distance, possibly from some of the elevated bottoms off the coast. The grown lobster is, as every lobster-fisher will know, in its whole mode of life, a genuine bottom-animal, and prefers a stony or uneven bottom overgrown with algæ where it finds good hiding-places for lying

in wait for its prey. During summer and part of autumn the lobster goes on higher bottoms in the bays and inlets, and is then frequently caught quite near the coast among the algæ at a depth of less than a fathom. Toward winter it again retires into the deep; and still later in the season it has almost entirely disappeared from those places where it was quite common during summer. Occasionally, however, it is, even in the middle of winter, found in deep water, and I have reason to believe that the lobster never leaves our coasts entirely, but considers it as its proper home.

As may be judged from its powerful claws, the lobster is a greedy animal of prey, which is not satisfied with small marine animals, but occasionally attacks all kinds of small fish which are unfortunate enough to come within its reach. The bait used for catching lobsters consists exclusively of fish, principally small codfish and herrings. These must, however, be tolerably fresh; as soon as they begin to get old the lobster leaves them to his cousins, the crabs, which are less fastidious in their taste, and they enter the baskets in great quantities.

The lobster is cautious and cunning. It never pursues its prey openly, but either endeavors to surprise it, in which it is greatly aided by its very highly-developed sense of smelling, or waits patiently among the algæ till some marine animal comes within reach of its claws. I have observed several times with what cautiousness and evident distrust the lobster, attracted by the bait, has gone round the traps and examined them several times on all sides before it has gone in. Only when it is very hungry, as is especially the case later in summer after the spawning and changing of shell is over, it is less cautious and will enter the traps more readily.

The lobster is best and fattest in spring and early summer, while later in summer and autumn it gets thin, from which cause the Englishmen will not take it then.

The propagating of the lobster does not seem to be strictly confined to a certain season of the year, as lobsters with roe may be found nearly all the year round. But the rule seems to be that the development of the young goes on during the summer months from the beginning of July till the early part of September. The more developed roe can easily be distinguished by its lighter color and partly also by the larger size of the grains. A closer examination shows distinctly in every grain of roe two dark spots which are the eyes of the embryo. The more distinct these spots are the more developed is the embryo. When its development is complete, the egg-shell bursts, and the young lobsters come out. These are in the beginning very helpless and sink to the bottom, where within a very short time they undergo their first change of skin; soon afterward the swimming apparatus, which has so far been surrounded by skin, begins to work, and the young lobsters soon gambol about in the water, and come up to the surface, where they remain during the whole time of their further development.

I have in the above-mentioned work (*Vid. Selskabets Forhandlinger* for 1874—Transactions of the Academy of Sciences) described the young lobster during this and the three succeeding stages of its development, and accompanied the description with plates. Each of these stages is characterized by a preceding change of skin; and each one of these changes makes the young lobster which in the beginning looks very unlike its parents, resemble them more closely. At the fifth change the metamorphosis is complete, and therewith ends its pelagian life. The young lobster has then entirely lost its swimming apparatus attached to the fore part of its body, and in its place the well-known fringes have grown at the lower side of the back part of the body. These fringes are the only swimming apparatus which the grown lobster possesses; in the female lobster, they likewise serve to keep the roe in position. The lobster now leaves the surface and goes to the bottom, there to lead the same life as its parents. I am not positively certain how long a time is taken up by the whole metamorphosis, but I am inclined to think that it takes at least a couple of months.

Even after the lobster has reached its final development, it continues to change its skin regularly at any rate once a year, and continues to do so as long as it grows. Only when it has stopped growing, this change of skin does not occur so often. We shall therefore always find that very large lobsters are more or less thickly covered with scales which is not so frequent in smaller specimens. The process of changing skin is very tedious and dangerous for the lobster, which may be imagined when it is known that not only the outer shell is changed, but even some of the inner parts, *e. g.* the stomach-bag. The process occupies a considerable time, and while it is going on the lobster is sick and utterly unable to fly from its enemies or to defend itself against them. It is therefore but natural that under such circumstances it very easily dies in the traps. Even after the change of skin is over the lobster remains weak for some time. It therefore hides among the stones at the bottom of the sea and remains there until the new shell has become sufficiently hard and its strength has returned.

The earliest changing of shell which I observed during my journey was in the first days of July near Tananger. I here had an opportunity to observe a lobster engaged in this process. It had just been taken out of a lobster-box and could be handled without offering the slightest resistance. The shell on its back was burst in the middle, and the tail and the feet were nearly all out of the old shell, while the largest claw only stuck out half its length. This latter portion of the change of shell is evidently very dangerous, and although I observed it for quite a while, I could see little or no progress. It is certainly a painful and dangerous process, and probably many a lobster loses its life through it. Immediately after the changing of the shell the lobster is lean and miserable and only reaches its former size after a considerable time has elapsed. According to my observations, the change of shell takes place

chiefly during the month of July. It certainly happens that some change later, but by far the larger number seem to change during that month.

I did not succeed in obtaining lobsters measuring from one inch to a finger's length, and as far as I know none are found in any museum. I consider it as certain, however, that the lobster keeps near the coast also during this stage of its development. The reason why they cannot be caught with the bottom-scraper is partly their quick movements and partly the circumstance that they hide among the algæ on the bottom of the sea. The fact that they cannot be caught in the common lobster-baskets is easily explained by these having such wide openings.

It is a remarkable fact that the lobsters on our southern coast never get as large as those farther north. I have never seen an unusually large specimen among the many lobsters which I examined at the different fishing-stations. The lobsters which are occasionally caught farther north are generally much larger, and to judge from their appearance much older. At Florö I once saw a lobster which was not much smaller than the immense specimen in the Bergen Museum. This specimen, as far as I remember, comes from a still more northerly point of our western coast.

As to its geographical distribution, the lobster is more of a southern animal than its cousin, the crab, which is found all along our coast as far as Vadsö. Its northern boundary is the polar circle. It is found very generally along the coasts of the North Sea and on all the Atlantic coasts of Europe, and even goes into the Mediterranean, where, however, it is not found in great numbers. The lobster found on the eastern coast of North America belongs to a different species, of which I convinced myself by examining its young ones, a picture of which I have given in the above-mentioned work.

From these scientific remarks I return to the practical side of the question. The principle which has been followed in framing laws for the better production of the lobster is the same which forms the basis of all similar protective laws, viz, a desire to let the propagating of the lobster go on as undisturbedly as possible. If one considers what an enormous quantity of roe a grown female lobster can carry under her tail, and also that this roe becomes impregnated, and that, consequently, every little grain of roe develops into a lobster, it is very natural to suppose that if only a sufficient number of female lobsters could hatch their young ones undisturbedly, ample compensation would be made for the number of grown lobsters caught every year. It was also very natural to suppose that the decrease in the quantity of lobsters, which had been observed in various places, was caused by catching grown female lobsters during the hatching-season. With other fisheries the use of certain fishing-implements has proved hurtful to the fish; but the implements employed in lobster-fishing are of such a kind as to preclude this possibility.

On general principles, the above-mentioned view seems to be entirely justified and logical. There is no doubt that if the lobster is let alone during the hatching-season a number of young ones will be produced large enough to compensate, under favorable circumstances, for all the lobsters which are caught. It is, therefore, only right that the lobster should be, as much as possible, protected during the hatching-season. It is likewise possible that reckless fishing during the hatching-season will hinder the increase of the lobsters. It must be remembered, however, that there are many other disturbing causes. I have already on another occasion shown that the young lobster during the first period of its life is exposed to many dangers, and that probably a large number perish on account of unfavorable influences during their development. If, therefore, in spite of protective measures a decrease in the quantity of lobsters has been observed in various places, it must not be supposed that the only cause of it is lack of protection or too short a season of protection. The season of protection is, in my opinion, correct on the whole, and if I now consider it best to set it a little earlier, viz, to begin the 1st July, I do this from another reason, viz, out of regard to the change of shell of the lobster, which begins during the first days of this month. The lobster is at that time entirely unfit for transportation, and many die even in the boxes. I believe that if the lobster is thoroughly protected during the months of July and August, there will be some guarantee at least that a sufficient number of young ones are produced to make up for all losses occasioned by the lobster-fisheries during the other months of the year.

But no laws and no protective measure can change the unfavorable physical conditions which have caused a decrease of the lobsters on certain portions of our coast. The only means to be employed under such circumstances is the artificial raising of lobsters. I shall have occasion to return to this point, and merely to avoid misconception, I will say here that I consider a reasonably arranged protection of the lobster not only desirable, but also necessary; but the protective measures should be somewhat uniform in the different districts. At any rate, on that portion of the coast which I visited, I found but very little difference both with regard to the time of hatching and the time when the lobsters change shell; so there is no reason for having a different season of protection in these districts. But as memorials have been sent to the department of the interior from several places asking for an extension of the protective season, it will probably be best, in order to avoid dissatisfaction, to leave it to each community to extend the season of protection wherever there is a very general demand for extension. But I must say that if protection is to answer its purpose, it will be necessary for the different districts to organize a system of superintendence, so the laws may be strictly carried out. As matters are now, there is—and I speak from personal observation—as much fishing going on on our southern coast during the season of protection

as at other seasons. Where the season of protection only lasts a month, those lobsters which have been caught when fishing is prohibited are generally kept in large boxes until the season of protection is over, when they are brought into the market. But many of these closely-packed lobsters die in the boxes, and those which are left are so lean and miserable that they are of little or no value, and are necessarily thrown away.

There is another point which I must briefly mention, viz, the artificial raising of lobsters. I have in another place expressed my opinion that this is a subject which possibly in the future may prove a very important aid to our lobster-fisheries. The exceedingly simple manner in which the artificial raising of lobsters can be carried on seems to encourage people in different places to make experiments in this direction. Mr. Hansen, a merchant of Akrevig, assisted by Mr. Olsen, superintendent of schools at Kobbervig, has already made several experiments, which, on the whole, have proved successful. During my journey of last summer I visited the place and examined the hatching apparatus, which had already produced a large number of young lobsters. Mr. Hansen has determined to make a kind of lobster-park, where the young lobsters, after their metamorphosis is completed, may live and develop. I consider these experiments of great importance, and would like to see Mr. Hansen receive sufficient aid from the government to enable him to carry them on on a larger scale and in a practical manner.

3.—ON DRAG-NET FISHING ON THE COAST FROM NEVLUNGHAVN TO TÖNSBERGFIORD.

With a view to examine in how far there was any cause for the government to take active steps regarding the memorial from the governor of the districts of Jarlsberg and Laurvig asking for authority to limit the use of drag-nets (beam trawls) on the above-mentioned coast, I made a journey (mostly by boat) along that coast, and staid a few days in each of the following places: Nevlunghavn, Fredriksværn, Kjærringvig, Sandefiord, and Bogen.

The result of my investigations is briefly as follows: Most of this coast is open toward the sea, with only short bays and inlets. Only in three places fiords run farther up the country, viz, the Laurvigfiord, with its branches, the Vigsfiord, the Sandefiord, and the Mefiord. An investigation of these fiords, in connection with information gathered from fishermen, has convinced me that there are no stationary schools of codfish in any of them, and that, in this respect, they are like the inner portion of the Christiania fiord and part of the Langesunds fiord. The codfish caught in these fiords come doubtless from outside, and most of them again return to the sea. It is quite probable that young codfish are found on this coast, and I certainly consider the reckless

fishing of these young fish with drag-nets as hurtful; but the same may be said of every other coast; but as the law proposed in the above-mentioned memorials only refers to fishing in the larger fiords where the codfish must be supposed to be rather stationary, it would not apply so well to this coast which is so open and unbroken. From what I have learned, drag-nets are rarely or never used here. Frequent conversations with fishermen have convinced me that there is no general dissatisfaction with this kind of fishing-implement, which is scarcely known here, but that there are complaints of an excessive use of hooks and lines. With the exception of the Christiania fiord, drag-net fishing has only been carried on to any extent in and near the Langesunds fiord, chiefly owing to local causes (the many quiet shallow inlets with even, sandy bottoms), which have made the use of this net more convenient here than on the other portions of the coast, which, both on account of the nature of the bottom and the open or unbroken character of the coast itself, is scarcely suitable for any extensive drag-net fishing.

Under these circumstances, I see for the present no necessity for the government to take any steps in the matter, and from another reason I would most decidedly advise not to make any law at least for the present. During my stay on the Langesunds fiord I learned that the regulations made in former times regarding the limitation in the use of the drag-net in the Langesunds fiord and its neighborhood, which are fully justified by local circumstances, do by no means produce the intended result, for I was told that drag-net fishing is carried on now to the same extent as before the law was passed. This is easily explained by the fact that there is no supervision whatever, although such supervision is absolutely required, since drag-net fishing is chiefly going on during the night or very early in the morning (before the break of day). Before there can be any talk of more rigid regulations of the drag-net fishing on coasts where the carrying out of such regulations would be doubtful, there must be some guarantee that these regulations are really observed, at any rate in those places where there is urgent necessity for such regulations. If this is not done, such rigid laws, far from doing any good, will do positive harm, as the moral influence on the sense of justice of the common people will be very bad, if there are laws which only exist on paper and can be transgressed with impunity at any time.

III.

EXTRACTS FROM PROF. G. O. SARS'S REPORT ON THE NORWEGIAN ATLANTIC EXPEDITION OF 1876.

1.—ZOÖLOGICAL OBSERVATIONS.

Among the various scientific problems to be solved by this expedition the most important was the examination of the biological condition of

those portions of the sea through which its route lay. The expedition was well supplied with all the necessary apparatus (bottom-scrapers, or dredges, trawl-nets, sieves, &c.), all according to the most recent English models; also a considerable quantity of cordage of different thickness, as well as heavy iron weights for keeping the apparatus on the bottom. A large number of glass jars of every size and quality, from small tubes to cylinders measuring one foot in diameter, were also on board, as well as a considerable quantity of spirits of wine for preserving the specimens which would be collected.

In order to take the best possible care of the zoölogical material obtained by the above-mentioned apparatus, and in order to make those preliminary observations which are of great importance for all future observations, it was thought best to have as many zoölogists as possible on the expedition, as well as an experienced draughtsman. The zoölogists were: Dr. Danielsen, Mr. Friele, and Professor Sars, and the draughtsman's place was filled by the well-known landscape-painter, Mr. Schiertz, whose skilled pencil and unusually sharp faculty of observation proved of great use to the expedition. He has produced a series of masterly colored sketches, which will form a great ornament to those zoölogical treatises which are going to be published as one of the results of the expedition.

The zoölogical work had been distributed in the following manner: Dr. Danielsen, assisted by Dr. Koren, was to observe and describe the echinoderms, gephyreans, and the coral animals; Mr. Friele, the mollusks; Dr. Hansen, the annelids; and Professor Sars, the other classes—crustaceans, pycnogonidæ, the polyzoans, hydroids, sponges, and those lowest organisms forming the connecting link between the animal and vegetable kingdoms (foraminifers, radiolariar, and diatoms). Professor Sars was also to make those observations which referred to the salt-water fisheries.

Every one of these gentlemen is now, and has been for some time, employed in working up his part of the material. But as this is exceedingly rich, it has not been possible so far to finish the observations and give a detailed report. As all the special results will, moreover, go into the general report which will be published at the close of the expedition, it will suffice in this place to give a brief account of the manner in which the biological part of the work has been done, and give some of the more important general results. It must be remembered that these observations, made far out in the open sea from a comparatively small vessel, and at a depth of nearly 2,000 fathoms, are, even under the most favorable circumstances, connected with very great difficulties, and take up considerable time. If, in spite of the long-continued unfavorable weather, a very large quantity of zoölogical material has been collected, this is chiefly owing to the zealous and skilful supervision of the work by the second officer, Lieutenant Pettersen, into whose charge it had been given by Captain Wille.

During the expedition the dredge was used sixteen times; the trawl-net, twelve times; the two combined, twice; and the swab, once. Altogether, not less than thirty-one separate hauls were made, and of these only very few were entire failures, while most of them yielded very satisfactory results. Besides this apparatus, the surface-net has been used very frequently for the purpose of examining the pelagian animals living near the surface. The dredge has also been used from boats in the Sognefiord, near Husö, near Thorshavn, on the Faroe Islands, and in the bay of Reykjavik. Without specifying the numerous animals brought up from the depth of the sea in this manner, it must be said that of nearly all classes new and interesting specimens have been obtained, extensive descriptions of which, accompanied by plates, will be published.

The greatest depth reached during the expedition was 2,000 fathoms, about half-way between Norway and Iceland, and several hauls were made at a depth of upward of 1,000 fathoms. The zoölogical observations were begun in the Sognefiord, where the considerable depth of 650 fathoms was reached, the greatest depth which had ever been examined near our coasts. Here the usual deep-water fauna was found, well known from former investigations, especially those of the Hardangerfiord, although several very rare specimens were also obtained; among the rest, a well-preserved specimen of the species *Brisinga*, given by Asbjórnsen (*Brisinga coronata*, G. O. Sars), several specimens of the interesting Gephyre *Priapuloides bicaudata*, Danielsen, hitherto only observed near Vadsö, and large numbers of a beautiful red crustacean with brilliant eyes shining like gold, formerly only found in very small numbers, *Munida tenuimana*, G. O. Sars.

The observations became more interesting when the expedition reached the barrier stretching at some distance from our western coast, whose outermost boundary is the so-called "sea-bridge"—(*Havbro*). Here begins, below a depth of 300 fathoms, the cold area or Polar Sea deep, which hitherto has been but little explored. It has a bottom-temperature of 0° to—1.6° C., and the fauna in accordance with this temperature has a very peculiar character, entirely different from that of our southern and western coast. Seventeen of our hauls were made in this cold area, and from these a tolerably correct idea may be formed of the peculiar physical and biological condition of this region. All over the large depression which occupied the greater portion of the bottom of the sea between Norway on one side and the Faroe Islands and Iceland on the other, the bottom at a depth of more than one thousand fathoms seems to consist of a peculiarly loose, sticky, light, almost grayish-white clay, which contains a great deal of lime, and, after being washed or sifted, proves to consist almost exclusively of shells of a very low organism, a foraminifer, the *Biloculina*. The expedition therefore called this deep-water clay "biloculina clay," to distinguish it from that kind of clay which is found in the warm area at a great depth in the Atlantic, and

which from a totally different foraminifer is called "*Globigerina*." The biloculina clay contains a great deal more lime than the globigerina clay of the Atlantic. When acids are mixed with it, gas develops very freely, and when pressed and dried, it soons turns into a very hard and compact limestone. We see here a complete lime or chalk formation during its period of growth, and its fauna also shows distinct traces of its ancient origin and its near relation to the remnants of organisms preserved in the fossil-bearing layer from the end of the Secondary Period.

We must here mention a beautiful stone lily (*Crinoid*) which measures a span in length, and is probably quite new, of which many live specimens were obtained, and which shows an unmistakable similarity to some of the oldest fossil forms of this group of animals, which is now almost extinct; also a very peculiar and interesting animal of the holothurian kind, enormous chalk-sponges, large numbers of a new and very peculiar pycnogonide, and a remarkable blood-red crustacean with integuments as thin as paper (*Hymenscaris*), besides several other new crustaceans. The mollusk which is most frequent in these parts is the *Siphonodentalium vitreum*, M. Sars, so characteristic of the older glacial clay, which on our coasts is only found alive in the northernmost part of Finmarken. Although the fauna of this great deep is of special interest from a zoölogical and geological point of view, it is on the whole rather monotonous. But where the bottom begins to rise toward the banks, a great difference may be noticed. At a depth of 400 to 900 fathoms, but still within the cold area, we find an exceedingly rich and varied animal life. Contrary to what might be expected from the low temperature prevailing here, we find, in comparison with our coast-fauna, no deterioration of animal life, but a remarkably luxuriant fauna showing itself in the numerous and varying animal forms, and in the comparatively colossal size which some of them reach, one of the polyps (*Umbellularia*) taken here measuring fully four yards in length.

From the specimens taken by the dredge, the trawl-net, and the swab, an approximate idea may be formed of the peculiar character of the bottom in these parts; forests of peculiar tree-like sponges (*Cladorhiza*) cover large portions of the bottom. Between their branches are seen magnificent medusa-heads (*Euryali*) and gaudy-colored animals of the *Antedon* kind, also different crustaceans; amongst the rest the fantastically shaped *Arcturus Baffini*, well known in the Polar Sea, and lazy pycnogonids, some of them of enormous size (measuring a span between the points of the feet), crawl about between the branches sucking their organic juices with their enormous beaks; also a large number of fine plant-like animals (polyzoans and hydroids) which live among the dead trunks and branches which have been deprived of their organic bark-substance. On the open plains among these swamp-forests, beautiful purple-colored sea-stars (*Astrophyton*) and long-armed snake-stars (*Ophiura*) may be seen, as well as numberless *Annelides* of different kinds; crusta-

ceans are swarming everywhere, long-tailed decapods (*Crangon*), finely built musidæ (*Erythrops*, *Parerythrops*, *Pseudomma*), large numbers of amphipods (*Anonyx*) and isopods (*Mumiopsida*). Like tall pine-trees rising above the lower forest trees, the gigantic umbellularia tower above all the rest with their straight trunks and beautiful tops garnished with fringed polyps. The light of day does not penetrate into these depths, but the animals themselves illumine these submarine forests, as nearly all of them are phosphorescent to a high degree, having the faculty of emitting from their bodies a very strong bluish, greenish, or reddish light.

Whenever the dredge or the trawl-net reached this region, which from its most characteristic animal form may well be called the region of the umbellularia, rich zoölogical results were obtained, and in most cases a day was too short a time to examine and preserve all these treasures brought up from the deep. Higher up, at a depth of 200–100 fathoms, and at a distance of 10–20 (Norwegian) miles from the coast, the long-stretched barrier commences, which, so to speak, forms the foundation on which our country rests and which separates it from the so-called Polar deep. This barrier generally commences with a hard stony bottom, and our dredgings were therefore connected with considerable difficulties. Numerous boulders, whose smooth round shape shows distinctly that once upon a time they have been exposed to the powerful influence of great masses of ice, are scattered about on the very uneven bottom, consisting of firm rock, and hinder the operation of the dredge or stop up its opening, so that in most cases only very imperfect specimens of the fauna of this region could be obtained. This fauna has a very different character from the preceding one, and resembles more the usual coast fauna; but it seems to be a rule that at this very point, the edge of the barrier, it is richer than nearer the coast, which seems to agree with the great wealth of fishes known to exist in these regions from olden times.

If in conclusion we combine all the physical and biological conditions—of which only a very superficial idea has been given here—in the portions of the ocean traversed by our expedition, the deeps surrounding our country may from a physiographic and zoögraphic point of view be divided into two very different regions, viz, the warm and the cold area. The former embraces the whole Skagerak and the North Sea and farther north the sea near our coasts till within a distance of 10–20 (Norwegian) miles, including all the fiords, and extends north to the northernmost point of Finmarken. The cold area begins where the bottom slants from the banks towards the great outer deep, extends in a southerly direction as far as the heights of Stadt, and continues in a southwesterly direction in the shape of a narrow wedge between the Faroe Islands and the Shetland Islands to the 60th degree of northern latitude. Towards the north the cold area extends to the North Pole, which is its central point. This area has been examined by the expedition at one

of its southernmost points, where it was found throughout to be very sharply defined from the warm area. The farther north one goes, the less marked does this boundary appear, as the cold area gradually rises from the deep, until in the Polar Sea it is even with the surface and then also occupies the littoral region, thus entirely excluding the warm area. The inner connection with the above-mentioned peculiar physical conditions of the seas surrounding our coast has been made a great deal clearer by the experience gathered during our journey, and an important contribution has been made to the meteorology of the sea in general. A further explanation of these purely physical conditions is also of the greatest importance to zoölogists for the better understanding of the different biological conditions of the sea; but as such an explanation belongs to the physico-meteorological observations, we shall confine ourselves to the purely zoölogical side of the question.

The character of the fauna in the cold area is purely arctic or glacial without any southern specimens whatever, and some of our varieties have already been identified with those gathered in the Polar Seas by the Swedish, German, British, and American Polar expeditions. In a higher latitude these animals, which in the sea traversed by us live only below a depth of 400 fathoms, and are therefore essentially deep-water varieties, live in comparatively shallow water, even up to the surface of the sea. This interesting fact seems to confirm the opinion expressed by several naturalists, that the distribution of animal life in the sea is chiefly dependent on the temperature, whilst the depth has but little influence on it. The purely arctic fauna found on our coast during the glacial period, and which has left its traces in the older glacial shell-banks, was gradually forced to retreat towards the deep, and this was chiefly occasioned by a change of temperature, which of course would be less perceptible in deep water. The place of this arctic fauna was then taken by animals immigrating from the south. In the deepest waters of some of our long and narrow fiords a remnant of this original arctic fauna may yet be found. But it evidently ekes out a miserable existence, which is sufficiently proved by the small size and crippled appearance of the animals. Their ultimate extinction is probably only a question of time. After the temperature of the sea has been studied more thoroughly, this can be fully explained from purely physical causes; for the influence of milder climatic conditions has finally also reached these deep waters of our fiords, so that even at a depth of 650 fathoms the average temperature is $+ 6^{\circ}$ C., a temperature which must certainly have a hurtful influence on the life of these arctic animals. The temperature outside of our sea-banks, even at a much lower depth, has, however, remained the same as it was in the glacial period here as well as close to our coasts. And we consequently find here, although remarkably far south, no sickly or crippled arctic or glacial fauna, but one fully as luxuriant as that of the Polar Sea.

The light which meteorology will be able to throw on some dark

phenomena in the development and distribution of animal life, and likewise the great aid which purely biological facts may furnish to meteorological investigations, make it desirable that these two sciences seemingly so different in their character should no longer remain strangers to each other, but should form an intimate union for the purpose of each contributing its share towards the scientific solution of several hitherto unexplained physical and biological problems which have greatly perplexed the man of science.

2—INVESTIGATION OF THE SALT-WATER FISHERIES.

Besides making strictly scientific investigations, it was likewise intended to observe, whenever an opportunity offered, everything which might have a bearing and throw some light on our important salt-water fisheries. As Professor Sars had studied our fisheries for a number of years, he was commissioned to make these investigations. A number of different fishing implements were therefore furnished to the expedition; *e. g.* hooks and lines and floating nets with different sized meshes. These implements could of course only be used in favorable weather, when the sea was tolerably smooth, which it was hoped would be the case at least part of the three months of the best season of the year occupied by this voyage. But the weather was unfortunately exceedingly unfavorable all the time, so that these fishing implements could scarcely be used at all. From the same reason another important apparatus for measuring the current, chiefly intended for physico-meteorological observations, could not be used. During the few days that the expedition enjoyed fair weather, it was too near the coast to make these investigations specially interesting.

Although the weather placed insurmountable hinderances in the way of the above-mentioned observations, several facts were nevertheless gained, which, in Professor Sars's opinion, are of importance and will serve as guides in future practical and scientific investigations of our fisheries.

The soundings show that there are several fishing-banks near our coast which hitherto have been entirely unknown, and where rich fisheries might be carried on during the summer months.

The so-called "Storegg" off the coast of the Romsdal District has from time immemorial been famous for its immense wealth of fish, and there are mysterious traditions that this is not the only point where similiar extensive fisheries could be carried on, but that there were other rich fishing-banks far out in the ocean, "if people only were fortunate enough to find them."

The mystic idea of the "Havbro", sea-bridge, has been to a great extent explained by the investigations of this expedition. The "Stor-

egg" is nothing else but a portion of the edge of that long barrier which forms our western boundary towards the cold polar deep. The natural reason why that portion of the barrier has been known for so long a time, without, however, leading to any correct knowledge of its exact nature, is this, that here the polar deep approaches nearer to the coast than at any other point, forming a very distinct bay. Even during the soundings made from the steamer Hansteen a new portion of the northern continuation of this edge was found, and its existence at several other points has now been proved, as well as the fact that both farther south and farther north it recedes from the coast to a distance of 20–30 (Norwegian) miles. Although this is not the case everywhere, the general rule seems to be that the bottom near the outer boundary of the barrier before sloping toward the great outer deep, rises a little and assumes a hard stony character, exactly like that of "Storegg."

The first line of soundings running from Husö in a northwesterly direction struck this edge at a distance of 20 miles from the coast (stations 16 and 17.)* The bottom, which had so far been soft, suddenly became hard and stony at a depth of 221 fathoms, and continued so even after it had fallen off 70 fathoms toward the outer deep. That the bottom here sloped off very abruptly was proved by the circumstance that at the next station the cold area was reached at a depth of 412 fathoms, and a bottom temperature of —1.3° C. Farther north, on the heights of Trondhjem, at a depth of 190 fathoms, and likewise on the boundary-line between the cold and the warm area, a similar edge of rocky bottom was discovered, falling off abruptly toward the west (station 89†). Similar discoveries were also made in the other portions of the sea traversed by the expedition.

Northeast of the Faroe Islands, and at a considerable distance from the same, the expedition was, in spite of the very unfavorable weather, fortunate enough to strike the outermost edge or the most northeasterly point of the long-stretched Faroe bank (station 38),‡ from which its extent and configuration could be somewhat determined, and the nature of this point seems to be very similar to that of the "Storegg." By the line of very careful soundings made from the Namsenfiord in a westerly direction, the existence of a hitherto unknown and very sharply marked cross-bank of considerable extent was proved; this bank extended at a comparatively short distance from the coast, at a depth of only 62–92 fathoms, and had a hard bottom (stations 63, 64, 65§). Outside of this bank the bottom sloped off very imperceptibly towards the great deep,

* The exact location of these points is given from the journal of soundings. Station 16: latitude, 62° 23.9′; longitude, 2° 17′ east of Greenwich. Station 17: latitude, 62° 33′; longitude, 2° 4′ east of Greenwich.

† Station 89: latitude, 64° 1′; longitude, 6° 7.5′ east of Greenwich.

‡ Station 38: latitude, 62° 57.4′; longitude, 3° 47′ west of Greenwich.

§ Station 63: latitude, 64° 41.3′; longitude, 9° 0′ east of Greenwich. Station 64: latitude, 64° 42′; longitude, 8° 50′ east of Greenwich. Station 65: latitude, 64° 42.5′; longitude, 8° 39′ east of Greenwich.

but nothing like the "Storegg" could here be discovered. It must likewise be mentioned that in the outer portion of the Sognefiord an extensive plateau was discovered with hard stony bottom and sloping both towards the coast and towards the deep (depth from 260 to 211 fathoms).

There can be no doubt that all the above-mentioned places are excellent fishing-stations. Wherever at some distance from the coast similar banks are found with hard or stony bottom, there have always been large quantities of fish, and although all attempts made during the expedition to attach a short line and baited hook to the plummet proved fruitless, no negative conclusion must be drawn from this very unpractical method of investigation, which under the circumstances was the only one possible.

The kinds of fish found on the banks are chiefly ling, cusk, halibut, and large codfish, the so-called bank codfish. Professor Sars has in his former reports to the department expressed his opinion that the so-called bank-codfish is not a different fish from the well-known winter codfish which comes to our coasts in winter and the beginning of spring for the purpose of spawning. The views formerly entertained of the migrations of the codfish from distant seas have been entirely abandoned by the professor, after he had thoroughly studied the nature of this fish, and the experience gained during this expedition has only served to corroborate his opinion. According to Professor Sars's opinion, all the codfish which visit our coast during the winter and which form the object of our most important fisheries are during the rest of the year found only in that portion of the sea whose bottom forms the barrier towards the outer polar deep as especially the outer side of this barrier (the so-called "Havbro") with its richly-developed animal life and the favorable character of its bottom forms a convenient place of sojourn for enormous numbers of codfish.

It is entirely different with another very important fish, *the herring.* Here the investigations made by Professor Sars have led him to the opposite view. While the cod is a genuine bottom-fish, and as such dependent on the nature of the bottom and the different depth of water, the herring is in its whole character a genuine pelagian fish, and therefore independent of depth of water and the nature of the bottom, but influenced by the physical and biological conditions of the water near the surface. As these change a good deal, this kind of fish had to be furnished with the means of quickly reaching the most favorable portions of the sea. The herring is therefore distinguished from the cod by its elegant compressed or wedge-shaped form, which enables it to shoot through the water as swift as an arrow and travel long distances in a comparatively short time.

The professor, although not taking the old-fashioned view that the spring herrings come from the ice-covered sea near the North Pole, inclines to the opinion that the herring undertakes long and irregular journeys in the open sea, not only when it comes to the coast for the

purpose of spawning, but all the year round. The distribution of the herring in the sea is dependent on the distribution of the small marine animals which form its food. These are all pelagian animals, chiefly small crustaceans which keep more or less near the surface and are well known to our fishermen by the name of "aat." Only when the herring comes to the coast in winter for the purpose of spawning, its migrations are, to begin with at least, independent of the occurrence of "aat." The rest of the year the schools roam about in the outer sea, chiefly seeking that portion where at different times they find the best supply of food. The great schools of herrings may therefore at the approach of winter or when the development of their generative organs drives them toward the coast in order to spawn there, be quite naturally either at a shorter or longer distance from their spawning places, just according to the quantity of food found in different portions of the sea. The professor thinks that this circumstance chiefly causes the fluctuations in our spring herring fisheries. As the migrations of the young herrings commence long before roe and milt are matured, the great mass of herrings, if near the coast at this time, would reach it so early that they would be obliged to stay here a longer time, and thus naturally get nearer the coast, entering the fiords and inlets. In the opposite case, if the mass of herrings should at that time be at a considerable distance from their spawning-places, such a long period of time would elapse before they reached these, that the spawning process could be performed immediately on their arrival. The herrings would in that case stay only a short time near the coast, and the spawning would chiefly go on on the outer and less accessible banks; in other words, the spring herring fisheries would be of very short duration or prove an entire failure.

This in brief is the theory which Professor Sars advanced several years ago, after having carefully examined our coasts, as the only possible scientific explanation of the remarkable irregularities which in course of time have been observed in the spring-herring fisheries. There were however at that time but few facts to support this theory. Sailors and fishermen had occasionally spoken of large masses of herrings which showed themselves far out in the open sea immediately before the spring-herring fisheries commenced; whilst others had at different seasons of the year observed large masses of small crustaceans in various parts of the sea. Regarding this last-mentioned phenomenon we likewise have the testimony of reliable naturalists (Kröyer), and from the very portion of the sea which is chiefly concerned here. But all this information is too scattered to prove in an incontrovertible manner that the open sea is really a fit place of sojourn for the enormous masses of herrings which come near the coast at different seasons of the year.

Professor Sars considered it as one of his most important objects on this expedition to examine the distribution of the "herring-food." With this view he examined the sea almost every day, frequently several times a day, with the surface-net. The results of these investigations

entirely confirmed his previous supposition regarding this matter. During the whole voyage from Norway to the Faroe Islands the sea was everywhere filled with enormous masses of the so-called "red herring food" (almost exclusively *Calanus finmarchicus*), which are well known as the favorite food of the herring; and it deserves to be mentioned that the quantity of these animals seemed to increase the farther we got away from the coast and reached its height at a distance of about twenty miles. Besides these animals we likewise observed occasionally farther out at sea another kind of a beautiful blue "herring food" (*Pontella Pattersonii*), which seemed to belong more to the Atlantic, and which in contradistinction to the former might be called "mackerel food," as it probably forms the principal food of the mackerel at those seasons of the year when they are not near the coast. This "food" is also occasionally found among the "red herring food" near the coast, especially during rich summer-herring fisheries. When the expedition took a northerly course from the Faroe Islands towards Iceland, it was very striking that the food seemed to have disappeared from the sea almost entirely. The water had at the same time assumed a very different color. While from Norway to the Faroe Islands it had a deep blue color, it now had a light grayish-green color. This peculiar circumstance, whose definite explanation has not yet been found, but with which the different currents of the sea have certainly something to do, seems to be closely connected with the occurrence of the "food," and will form a subject of investigation for the next expedition. Professor Sars says that he had a very excellent chance to observe this phenomenon from his state-room, whose window was on a level with the water. Whenever the waves covered the window his whole state-room was formerly filled with a dark blue light, whilst now it was a bright greenish light. This color remained as long as the vessel was in Iceland waters, and here the sea did not contain any food whatever. Only when on our return voyage we approached the coast of Norway the sea again showed its blue color and was full of "food."

It must, however, be supposed that the conditions observed during our voyage are not always the same, as some reports say that the sea near Iceland is peculiarly rich in "food." It seems as if the steady westerly gales which prevailed during the expedition, in connection with the strong eastward current, had brought the great masses of "food" nearer to the coast of Norway. If this should really have been the case, which, however, can scarcely be proved conclusively, it would, in connection with Professor Sars's theory regarding the migrations of the herrings, be an indication that the spring-herring fisheries would again be successful in the near future. It may be considered as absolutely certain that wherever there is "herring food" herrings will be found. Although there was unfortunately no chance to corroborate this by direct investigations made by means of floating nets, the indications were by no means wanting that there were herrings where the "food"

was most plentiful. Not a few whales were noticed in these localities, also a large number of sea-birds, and at a considerable distance from the coast, near stations 75 and 76,* large brown spots could be observed in the sea resembling extensive algæ-bottoms, which, however, on close examination proved to be enormous masses of closely packed "food," on which the *Procellaria glacialis*, the constant companion of our voyage, was feeding to its heart's content. It is evident that these enormous masses of "food" had not come here accidentally, nor could it be supposed that far out in the open sea the current alone could have done it. It is much more probable that the schools of herring had chased it here, and that under these brown spots there were dense masses of herrings.

It was very unfortunate that unfavorable circumstances did not allow the use of floating nets, by which the occurrence of the herring in the open sea could easily have been proved. It is to be hoped, however, that the next exhibition will be more successful as regards the weather, and that the herring question will be made more of an objective point, all the more as the expedition will go farther north, *i. e.*, nearer those waters which Professor Sars considers the home of the spring-herring and the great-herring.

IV.

PRELIMINARY REPORT ON THE ZOÖLOGICAL OBSERVATIONS MADE DURING THE SECOND NORWEGIAN POLAR EXPEDITION OF 1877.

The expedition left Bergen on the 11th of June and returned to that place on the 23d of August, and therefore lasted about three months. Its outfit was about the same as during the preceding year. The zoölogical *personnel* was also the same, with the sole exception that Dr. G. A. Hansen accompanied the expedition as passenger, and during the first month also as zoölogist instead of Mr. H. Friele, who was detained by his business and only joined at Tromsö.

Different from last year, the weather was nearly all the time unusually calm, with northerly wind and a comparatively smooth sea, so that even the finest microscopic observations could be made on board. In consequence of the favorable weather the number of working-days was a great deal larger than last year, and the number of stations, which had been ninety-five last year, was almost twice as large.

This expedition investigated a considerable portion of the Northern Sea, viz, from the height of the Vigten Islands (65° northern latitude), which were reached last year, as far north as 71½° northern latitude, and as far west as 11½° western longitude. Eleven different cross-lines were followed in different heights, and some of them a very considerable

* Station 75: Latitude 64° 47.2′; longitude 7° 13′ east of Greenwich. Station 76: Latitude 64° 47.4′; longitude 7° 3.6′ east of Greenwich.

distance from the coast. Two of these lines go across the Northern Sea, or across 20–24 degrees of longitude. Observations have also been made at other points wherever there was anything of interest, thus in some of our deep fiords, the Saltenfiord, the Westfiord, and the Ulfsfiord north of Tromsö. Our stay on the isolated volcanic island of Jan Mayen, which lies far out in the Northern Sea, was of the greatest interest both from a physical and biological point of view. We spent a week on this island, examining its fauna, flora, and geology, as well as the surrounding sea. The results obtained by these observations will throw light in many directions and extend our knowledge of the Northern Sea, with its peculiarly grand scenery.

The dredge was altogether used twenty-nine times, and the trawl-net eight times (occasionally both combined), and in most cases with a very satisfactory result. Of all the hauls, twenty-four were made below 200 fathoms, fourteen below 500 fathoms, and six below 1,000 fathoms. The greatest depth reached was about midway between Norway and Jan Mayen, about 2,000 fathoms. Hauls were made from on board the ship, both here and at Jan Mayen, and at different points of our northern coast; but quite frequently hauls were also made from a boat; and important additions were made to our knowledge of the arctic coast fauna. Wherever there was a chance, the surface-net has been used, and a number of important observations have been made in this manner.

I have already in my last report directed attention to the interesting fact that the bottom of the Northern Sea as far as the 60th degree of latitude embraces two faunas totally different in their character, the one of purely arctic or glacial origin, the other chiefly containing southern animals. It has also been mentioned that each of these faunas has its distinctly-defined area at the bottom of the sea, without regard to the degree of latitude, and often side by side, corresponding with the two physically clearly-defined areas, the warm and the cold. Wherever the bottom of the sea outside the outer banks slopes off 300–400 fathoms, the deep-water fauna of our coast-waters suddenly changes to the entirely different and peculiar glacial fauna represented by gigantic and luxuriantly developed animal forms, some of which have been already observed, but only very far north in the ice-filled waters of the polar regions. This characteristic glacial fauna was of special interest to us, and it yielded the most important scientific results. These results have increased by our continued investigations of the cold area, and many new and interesting animals have been discovered. Our knowledge of the general character of the deep-water fauna, of its relation to the faunas of other seas, and of the physical conditions on which the distribution of animal life at the bottom of the sea depends, has likewise been greatly increased.

In the extensive area of the Northern Sea, which was investigated by us during this expedition, we found below a depth of 800 fathoms the light plastic biloculina clay with its limited but to a high degree pecu-

liar and interesting fauna. The richest development of submarine animal life was always found in those places where the bottom began to rise from the great deep toward the banks, especially where it rose abruptly and where the clay was more or less mixed with sand. Here is the home of the colossal Umbellulariæ, and associated with them we generally found a large number of different gaudy-colored marine animals, which give this whole region its peculiar character. This year we likewise obtained some very fine specimens of Umbellularia, but neither as many nor as large ones as last year, which seems to indicate that it is confined to certain localities.

An examination of this region yielded several new and interesting specimens, especially Echinoderms, Actinia, and Mollusks. It was of special interest to us to discover here such highly-organized animals as fishes. In one of our hauls (station 124) two different kinds of a peculiar arctic fish, *Lycodes*, were caught at a depth of about 400 fathoms and a bottom-temperature of 0.9° C.; one of these fish had hitherto only been found in the Polar Sea, and the other was entirely new. Our dredgings did not always yield such good results. Not unfrequently we found even in the Umbellularia region unusually poor and barren places, a kind of submarine swamps, where the dredge like an anchor sank deep into the mud, and was quickly filled with a peculiar soft, tough, bluish clay containing scarcely any sand. Wherever the bottom was of this character we were prepared for poor hauls. The difficult and wearisome examination of this tough clay produced only very few and low animal forms, often nothing but a few *Lumbrinereis* and a peculiar *Sipunculide* already observed last year, which seemed to flourish here, as we found them in larger numbers and of greater size than anywhere else. There is no doubt that the nature of the bottom plays a much more important part in the distribution of marine-animal life than has hitherto been supposed. The experience gained during our two expeditions furnishes convincing proof that even the slightest change in the composition of the bottom produces a very noticeable change in the character of the fauna. The different depths which formerly were thought to have a great deal to do with the character of the fauna, seem to have much less influence on it, as our observations have proved that one and the same animal may be found at very different depths, if only the nature of the bottom and the temperature remain unchanged.

As I remarked in my last report, the boundary of the cold area is found in the southern portion of the waters examined by us at a depth of about 300 fathoms. It might be expected that this boundary, the farther north we get, will gradually rise higher, as in the farthest north the cold area embraces the whole sea from the bottom to the surface. We were therefore at first surprised not to find the cold area near Vesteraalen, until we reached a depth of 400 fathoms, therefore even deeper than where we had found it six degrees farther south. This peculiar circumstance, and the corresponding unequal distribution of animal life

at this point, was satisfactorily explained by the unusually abrupt sloping of the banks toward the outer deep and the exposure of this locality to the warm northeasterly Atlantic current. Last year already we observed near "Storegg" a similar very noticeable depression of the cold area occasioned by the warmer current flowing back from the abruptly rising "havbro."

Similar irregularities in the temperature of the sea, most of which could be explained by the peculiar formation of the bottom, were observed farther south near the Vestfiord and the coast of Nordland. But as all this belongs more to the physical part of our observations, I will not dwell on it any more, but will briefly relate how we found matters on the opposite (the western) side of the Northern Sea near Jan Mayen. Just as strange as this island appeared to us with its plains covered with black volcanic sand, its shallow lagoons, its chief mountain, the Berenberg, rearing its crater-shaped summit among the clouds, and its mighty glaciers sloping toward the ocean, just as strange was the nature of the surrounding sea. A few fathoms below the surface we found ice-cold water, and even the temperature of the surface-water rarely exceeded a few degrees. There was consequently scarcely any warm area, and the cold area predominated. But it must be remembered that we were here under the direct influence of the Polar current. The warm Atlantic current does not extend its beneficial influence to this barren and monotonous island, which the greater portion of the year is covered with snow and ice and enveloped in the dense fogs of the Polar Sea. The Atlantic current passes a few degrees farther south, bounded by the cold water of the Polar Sea, toward the more favored eastern portion of the Northern Ocean, where its influence is felt as far north as Spitzbergen, which in spite of its more northern latitude, at any rate on its western coast, has a much milder climate than Jan Mayen.

Corresponding with the peculiar physical condition of Jan Mayen, we found that the fauna at every depth, even up to the littoral zone, had a completely arctic or glacial character without any southern elements whatever. The dredgings made near Jan Mayen were of an exceedingly interesting nature, and gave us a very correct idea of the rich animal life which is found here in spite of the unfavorable temperature of the sea. We found a very large number of Echinoderms, some of them of enormous size and beautiful colors; likewise different peculiarly-shaped mollusks, among the rest gigantic live specimens of *Arca glacialis*, so characteristic of our older glacial period.

It was also of interest to us to find here at a depth of 60–80 fathoms some of our old acquaintances from the enormously deep cold area farther south. Nearly all animal types were represented, not even excluding fish. The dredge thus brought up from a depth of 200 fathoms no less than three different kinds belonging to those fish found near Greenland. But not only the bottom of the sea but also its surface was full of animal life, which might be seen from the enormous flocks of birds

which partly covered the water and partly were busy flying to and fro, having to feed besides themselves their greedy young ones sitting in their nests on the barren rocks of Jan Mayen. By means of the surface-net we gained considerable knowledge of this pelagian fauna. In certain places the sea was swarming with the well-known "herring-food" (*Calanus finmarchicus*), but most of them three to four times larger than those on our coast. In other places, we found enormous numbers of a winged snail peculiar to the Polar Sea (*Limacina helicina*) moving about in the water with great rapidity, by means of its wing-like organs of motion, also specimens of the peculiar transparent "whale-food" (*Clione limacina*), the principal food of the Greenland whale. It was exceedingly interesting to observe that the surface-water for miles and miles, especially where the lower temperature indicated the close proximity of ice, was literally filled with a shapeless organic matter which gave a grayish-green color to the water. If a fine tulle surface-net was dragged after the vessel, it could be noticed, after the lapse of a few seconds, by its resistance, that it had become useless. When taken out of the water it was found to be thickly covered and its inside filled with a yellow-brownish gelatinous slime, emitting a peculiar organic odor. All the fine meshes were so completely stopped up that water only flowed through with difficulty. Seen under the microscope (magnified 800–1,000 times in diameter), this gelatinous matter was found to consist of live protoplasm of the simplest composition imaginable, and aggregated in irregular large and small lumps.

Among this protoplasm we found, but only sporadically, diatomic shells and other microscopic bodies, among them not a few of the peculiar calcareous concretions, coccolites and cocco-spheres, known to us from the Atlantic deep. Already at our first station to the northwest of the Vigten Islands we had observed a similar sea-slime, but not in such large quantity; and the microscopic examination proved that it consisted exclusively of formed organisms, especially a peculiar diatom (*Chætoceros*), each of which has a regular shell terminating in four long horns, all of them being united in long thread-like chains. Many years ago I observed a similar organic slime in the Christiania fiord early in spring or immediately after the ice had broken; the fishermen called it "Gro," and on closer examination it was found to consist almost exclusively of the above-mentioned diatom. I have learned later that this same phenomenon has been several times observed by other naturalists, especially in the Arctic Seas near Spitzbergen and Greenland, where this slime gives a peculiar color to large portions of the ocean. So far, however, no thorough microscopic investigation has been made of this organic matter found in the Arctic Sea. I can, at any rate, not find any record of any one having discovered free protoplasm in this slime such as I certainly found in the slime near Jan Mayen. Wherever I find this sea-slime spoken of, it is said to consist chiefly of diatoms. But what gives such great scientific interest to this phenomenon is the remarkable

fully-proved fact that at any rate in some cases it may consist entirely of a shapeless organic mass which certainly in its composition corresponds with the matter contained in the individual diatoms, but differs from it in this respect that it has not yet become individualized, but forms an unlimited and shapeless aggregation of protoplasm.

I have devoted more time to this phenomenon because it is of vast significance not only from a scientific but also from a practical point of view. This became immediately clear to me, and laying everything aside I devoted two whole days to a continued and searching microscopic examination of the above-mentioned protoplasm, in which I was favored by unusually calm weather and a smooth sea, our steamer lying still or floating with the current, as its boiler was being cleaned at the time. When I made these investigations I certainly did not know that such a slime had been observed by other naturalists, but even now, after I have studied all that has been written on the subject, I am convinced that the time spent by me has not been thrown away, as the sea-slime near Jan Mayen was of a very peculiar character, and as this phenomenon will lead to several highly important conclusions which will not only throw light on the biological condition of the Arctic Sea, but will also touch some other questions of the greatest importance. I hope at some future time to give a full account of this phenomenon, and of the conclusions which may be drawn from it. I will here only direct attention to the important scientific fact that in this protoplasm we have the simplest imaginable organism, neither animal nor plant, standing far below both, without shape, without limitation, not even yet separated into individuals, much less having any organs, a shapeless, indifferent, organic matter, which nevertheless contains life, but life of the simplest and most primitive kind.

It is well known that in the first preliminary reports of the British expeditions a very remarkable and problematic being has been frequently spoken of, which was called *Bathybius*. This *Bathybius* was described as a shapeless organic slime which, below a certain depth, was supposed to penetrate the loose material of the bottom of the Atlantic, and produce its viscidity. But the existence of this mysterious being, which for a time created such a sensation in the scientific world, has recently been doubted by several naturalists; and with very good reason, for the microscopic examination of this bottom-slime was not made on the spot on board the ship, but on the return of the expedition, on specimens preserved in spirits of wine. It is obvious that even the most careful and conscientious examination, if made under these circumstances, would easily lead to mistakes; and it has actually been discovered that when spirits of wine is mixed with sea-water containing decomposed animal matter, a gelatinous sediment is formed, which resembles very closely the picture of the *Bathybius*. Grave and, as it seems, well-founded doubts have thus been raised as to the existence of

any such protoplasm at the bottom of the sea, and the once famous *Bathybius* is gradually being swept away by the stream of oblivion.

It is therefore a fact of the greatest interest that just as simple, just as shapeless, and just as unlimited an organism has been proved to exist not at the bottom of the sea, but near the surface of the Polar Sea whose waters are filled with melting ice. The careful microscopic observations made on board, and the drawings made of the fresh and living protoplasm, will in future exclude every doubt as to its existence. The *Bathybius* has thus in a manner been resurrected, although the nature of the protoplasm spoken of here will make it necessary to give it another name. The scientific interest taken in this protoplasm will be the same as that once taken in the now defunct *Bathybius*.

I said before that this sea-slime would be of great interest even from a practical point of view. I shall return to this subject in the report which I intend to publish on the practical and scientific investigations of the fisheries made during this expedition. It will be sufficient in this place to direct attention to the circumstance that the very occurrence of this organic matter in the arctic waters is the principal cause of its great wealth of fish, and especially of the large number of individuals of certain species which form the chief objects of our most important fisheries, principally pelagian fish, herring and mackerel, but also, though more indirectly, codfish and pollack, in as far as both these fish of prey feed to a great extent on the two first-mentioned fish.

This is scarcely the place to give a detailed account of the many new and interesting discoveries in the different branches of zoölogy which were made on this expedition. I will only say in conclusion that if we review all that has been done by the expedition in different directions, we ought to be well satisfied with this year's results. The practice and experience gained during the preceding year, together with the favorable weather and the lively interest taken in the expedition by all its participants, have all contributed their share toward its success, and we are fully justified in expecting that the next expedition, which is to go out in 1878, will increase still more our knowledge of the physical and biological character of the Northern Sea.

V.

REPORT ON THE PRACTICAL AND SCIENTIFIC INVESTIGATION OF THE SALT-WATER FISHERIES, MADE DURING THE SECOND NORWEGIAN POLAR EXPEDITION OF 1877.

Although the Storthing (Norwegian Parliament) has for every financial year appropriated a considerable sum for continuing the practical and scientific investigations which I have carried on for a number of

years, I thought that the favorable opportunity for making these investigations offered by our polar expeditions should certainly be used, instead of making special journeys which would have to be paid out of the appropriation. This arrangement has proved very advantageous both from a pecuniary and a scientific standpoint, as during the last two years only a very small portion of the appropriation has been used, and this although important investigations have been made.

It will be remembered that last year already I published the results of the investigations made by me during the first expedition. During the second expedition I likewise considered it as one of my most important objects, not only to make strictly scientific zoölogical observations, but also to observe everything which might throw more light on our important fisheries. Among the questions touching the practical fisheries there was the exact placing on the maps of the outer banks (the so-called "Havbro"), and the searching for localities which, like the famous Romsdal banks ("Storegg") might prove successful fishing-places. As the outer banks generally form the boundary between the cold and warm area, and as it was of great importance from a purely scentific standpoint to determine the exact boundary, the physical and biological investigations had in a measure to take the same direction as the practical and scientific observations; and we consequently concentrated our attention on the solution of this problem. On the cross-lines running perpendicularly toward the coast all these points were carefully examined; and the stations which are closer together here will also show on the maps the conscientious methods of our investigations.

It thus became possible to obtain a tolerably correct idea of the configuration of this whole long-stretched barrier which on our western and northern coasts shelters us from the cold area and forms the outermost limit of our coast-waters.

If one connects the different stations examined by us on our two expeditions, by a curved line, at a depth of about 300 fathoms, which depth indicates the boundary-line between the cold and the warm area, it will be found that this curve at a different height has two distinct indentations in a northwesterly direction from the coast, and here the boundary line between the cold and the warm area is consequently nearer the coast than at any other point.

One of these indentations in the submarine barrier is off the coast of Romsdal about ten miles from the land, and is bounded by the well-known fishing-station of "Storegg." The other is four degrees farther north on the outer coast of the Loffoden, and near Vesteraalen, still nearer to the coast, and is bounded by a similar distinctly-marked barrier ("Eg"), the "Lofot-egg" or "Vesteraals-egg." Midway between these two indentations, northwest of the Vigten Islands, the curve runs again more than forty miles from the coast, and north of Tromsö it makes a very sharp turn. If similar curves are drawn at a depth of 400, 500, 600 fathoms, &c., it will be found that at the two above-mentioned places, the

"Storegg" and the "Lofot-egg," these lines are close together, while north and south of these places they diverge again. Even in a curve of 1,500 fathoms depth the two indentations are distinctly marked.

It follows from this that near Romsdal and the Loffoden Islands, the submarine barrier slopes very suddenly toward the great outer deep, while in other places the slope is more gradual. And in connection with this the bottom is of an essentially different character. Wherever the slope is gradual there is a good deal of loose material, clay or mud, but where it is abrupt there was no chance for any loose material to gather, and we find generally only firm rock, bowlders, pebbles, or coarse gravel. It is the very kind of bottom which the fishermen designate as a good fishing-bottom; and wherever this bottom is found far out at sea, there are large numbers of codfish, ling, cusk, and halibut, while the soft clay bottom is by no means so productive, and is chiefly inhabited by skates, dog-fish, and similar fish.

The new barrier which we discovered near the Loffoden Islands and Vesteraalen possesses all the essential conditions for serving as a place of sojourn for large masses of the above-mentioned important species of fish; and not only the barrier itself, but all the inner coast-waters near it possess similar advantages. The place where the "Lofot-egg" is nearest the coast is near the northern point of the island of Langö, about four miles from the land. We thought it best in this place to stop our sounding operations for a while and make a few observations of a more practical nature. Although the current was very strong, driving the ship forward, we nevertheless succeeded very soon, by means of our lines and hooks, in furnishing direct proof of the wealth of fish in this easily-accessible place. Among the considerable number of fish which soon lay sprawling on deck there were large codfish, ling, cusk, and halibut, therefore all the characteristic species of bank-fish. All this portion of the coast-waters from the heights of Röst till north of Tromsö will doubtless furnish suitable places for rich bank-fishing during summer, and rich hauls will be made on the barrier itself, whose exact location has now been determined and has been marked on the map. As this barrier is nearly along its whole length nearer to the coast than the "Stor-egg," the practical value of these waters for fishing will be all the greater.

It has already been mentioned that the physical conditions of the "Lofot-egg" very closely resemble those of the "Storegg." We also find another very significant resemblance: Along the coasts inside of these barriers very extensive spring cod-fisheries are carried on during winter. The cod-fisheries near Aalesund have long been famous, but they can bear no comparison with the immense Loffoden fisheries, which are sure every year. It might, in this connection, not be out of place to ask the old and much-disputed question, "Where do the codfish come from?" It is well known that not only fishermen but also naturalists have generally inclined to the opinion that the codfish come a long distance

across the great ocean; and some even thought they could discover a direct connection between the Newfoundland, Iceland, and Loffoden cod-fisheries, according to which theory the same schools of codfish would every year describe the circle of the ocean. The careful observations of the mode of life and development of the codfish which I made during several journeys to the Loffoden Islands have led me, however, to an entirely different result; and I have already in my first reports to the department advanced the same opinion, which I hold still after having gained much more experience, viz, that the codfish is not a migratory fish, like the pelagian fish, the herring and the mackerel, but belongs to the coast-waters, especially their outer portion, the so-called sea-banks.

In my later reports I have endeavored to prove that the so-called "bank fish" differs from the codfish proper only in name, but is really the same fish. This opinion, which, as I was told, for a time met with great opposition among fishermen and other persons interested in the fisheries, has been fully corroborated by the observations made during our expedition. We have now proved conclusively that the nature of the bottom near each of the two most important codfish districts possesses physical conditions which make it peculiarly suited as a place of sojourn for large numbers of codfish and similar fish. Near the Aalesund district we find the "Storegg," known from time immemorial as a good bank-fishing place; and near the Loffoden district we find a barrier of exactly the same nature. But in the same proportion as the Loffoden fisheries are more important than the Aalesund fisheries, the newly-discovered "Lofot-egg" is of much greater extent than the "Storegg." On this long-stretched barrier, extending along the outer coast of the whole Loffoden group, and as far north as the heights of Tromsö, and in the inner coast-waters, there is sufficient room even for such enormous masses of fish as come near the Loffoden Islands in winter.

The question might finally be asked here, why the codfish and similar fish of prey prefer such places as those mentioned above, and why they do not stay in other parts of our extensive coast-waters? The answer that in these places the bottom is of a peculiar nature will not suffice here. We must also try to explain why this nature of the bottom has such a remarkable influence on the distribution of the codfish. It is doubtless not a mere whim which makes the codfish select these places, and it is scarcely probable that it should show a preference for a certain kind of bottom and an aversion to another merely on account of its character. There must, therefore, be another cause which must have some connection with peculiarly favorable conditions for obtaining food. It would be of the greatest interest to have this question solved; and the exact physical and biological investigations made at these points assumed all the more significance, as they were made not merely in the interest of science, but with a practical purpose. The zoölogical investigation

of the bottom in these places has shown that there is a rich animal life; but the difference in this respect between these and other points of the wide-stretched submarine barrier was not so striking as to furnish a satisfactory solution of the problem. There is another circumstance, however, which has much greater weight, and which is fully proved by our investigations, viz, that near such abruptly-rising submarine banks as the "Storegg" and the "Lofot-egg" there exist peculiar physical conditions which make it highly probable that the codfish and other fish of prey have a better chance here than in other places to intercept the large herring schools. It is not purely accidental that the two above-mentioned indentations in the submarine barrier, with their abrupt banks, are in close proximity to the two most important herring districts. That there is really some close connection between the two I shall endeavor to prove in the following.

The occurrence and distribution of the herrings in the ocean is, generally speaking—as I have tried to prove on former occasions—undoubtedly dependent on the occurrence of the "herring-food," and this is again dependent on the currents of the sea. Wherever different currents strike each other the "herring-food" is always piled up in enormous masses, and these are the favorite "feeding-places" of the herrings.

It is well known to fishermen and sailors that wherever the banks slope abruptly toward the sea, *e. g.*, near the "Storegg," there is a particularly strong current, so that the location of the bank may be determined by this. The different, often entirely contrary, currents which meet here produce a very striking sort of whirlpools on the surface of the water, which in stormy weather become dangerous for vessels. When, some years ago, attracted by the mystery enveloping the "Storegg," I made an adventurous expedition to one of these distant fishing-places, in an old boat manned by four sailors, I had ample opportunity to observe this phenomenon, whose natural explanation is no longer difficult, after the observations made by our expedition. There is in these northern seas a constant forward movement, not only of the upper but also of the lower portions of the water, in a northeasterly direction, therefore toward the coast of Norway; and this motion is evidently connected with the warm Atlantic current. Wherever the slope toward the deep is gradual, no disturbance will be noticed in this motion; but when the advancing mass of water strikes an abrupt slope the equilibrium will be considerably disturbed, and this will have both an upward and a downward influence. On the surface of the water different currents will be produced, and farther down the reflux of the warmer water will exercise a noticeable depression of the deepest cold strata—a phenomenon which has been witnessed both near the "Storegg" and the "Lofot-egg," where the cold area does not begin till a depth of 400 fathoms is reached.

But what chiefly interests us here are the disturbances near the surface, the different currents. During our first expedition these currents were observed at the same place where I had formerly noticed them, viz,

near the "Storegg"; and during our last expedition the same peculiar currents were, to some extent at least, also observed near the "Lofotegg." It is evident that the "herring-food" and with it the herring-schools will oftener gather here than in most other parts of the sea, and as neither the one nor the other is strictly bound to the surface, but from various causes often go deeper, the fish of prey living near the barrier have ample opportunity to mingle in this game.

Although the bottom codfish or algæ codfish living nearest the coast, which are in reality nothing but younger codfish, are not very fastidious in the selection of their food, there is every reason to suppose that the full-grown bank codfish, or codfish proper, found near our coasts make the herring, if not their exclusive, at any rate their chief food. If the Northern Ocean did not harbor these large masses of herrings, there would not be sufficient food for the enormous number of codfish which in winter come to the coast to spawn, and which during that season form the most important object of our fisheries. Here as everywhere in nature there is a close connection between cause and effect, which from a practical point of view we must explain and follow up to its last consequences in order to get a clear idea of all those conditions which have an influence on our fisheries.

There is, as I said, every reason to suppose that our wealth of codfish and similar fish of prey is chiefly dependent on the herrings in the outer waters. And the herring again is dependent on the "herring-food" found in the open sea. Without its great wealth of "herring-food" the Northern Ocean could not support the large masses of herrings, and these again support the codfish found in our coast-waters. The "herring-food" is, like the codfish and the herring, an organism which cannot possibly live on nothing, but which in order to make its appearance in such enormous masses must find a sufficient quantity of food in the sea. But what constitutes its food? We have here reached the last link in the chain of evidence, a link which is of the greatest importance, as all the others depend on it. During our last expedition we had an opportunity to make observations with regard to this important point.

I have already mentioned in the partial report on the zoölogical results of our last expedition, that in the sea near Jan-Mayen, and especially where the low temperature of the water showed that it was mixed with ice-water, we found enormous masses of a peculiar organic matter, a kind of yellowish-brown slime, which colored the sea-water for miles. Accurate microscopic observations proved it to be a shapeless, indifferent, but living protoplasm. Farther south, on the height of the Vigten Islands, we found a similar sea-slime, differing, however, from the former by its consisting of formed microscopic organisms, chiefly a peculiar kind of diatom. In my zoölogical report I have directed attention to the great scientific interest attaching to the slime observed near Jan-Mayen. From a more practical standpoint both kinds will be of equal interest. We have here possibly two different links in our chain of

evidence, instead of one. The first link would be the shapeless Jan-Mayen protoplasm, on which the formation of the diatom-slime occurring farther south depends. It is evident that this sea-slime, which both according to our and to former observations is found all over the Arctic Ocean, plays a very important part in the large household of nature, furnishing an unlimited quantity of organic food, which makes the existence of myriads of small animals—in our seas chiefly the "herring-food"—possible. If we consider that these enormous masses of "herring-food" are, as we have proved conclusively, an essential condition of the great wealth of herrings, and these again of the wealth of cod-fish and other fish on which the welfare of our coast-population depends, it will become evident to every one that the question is a very important one.

In a recent interesting work on the fisheries of British North America, by Professor Hind, of Halifax, in which credit is given to the practical and scientific investigations made on our coasts, the great importance of the sea-slime of the Polar Sea for the Labrador and Newfoundland fisheries is clearly pointed out. It is certain that this sea-slime is of the same great importance for our Northern Sea, and we even go farther, and maintain that its far-reaching influence extends to every sea. The last great British expedition on board the Challenger observed similar sea-slime in the southernmost portion of the Atlantic, increasing in quantity the nearer they came to the Southern Polar Sea. This sea-slime seems everywhere to have its origin in the icy waters near the poles, whence it is distributed by the currents of the sea to a greater or less distance into the more temperate sea. We therefore arrive at the very unexpected result, that the inhospitable icy sea of the polar regions furnishes the fundamental condition of the inexhaustible wealth of the more temperate seas.

The origin of this primitive food is an unsolved problem. It is certain, however, that it is found in largest quantities in places where the ice melts under the influence of the summer warmth, and whalers are said to have observed that the lower side of the melting and floating ice is covered by a thick layer of a similar slime. Near the coast of North America this sea-slime is brought direct by the polar current from the Greenland Sea to Labrador and Newfoundland. On our coasts, which are not under the direct influence of the polar current, but under that of the warm, northeasterly Atlantic current, this addition of polar water to our seas is less regular, but evidently takes place, as the sea-slime from the Polar Sea was by our expedition observed in several places, even as far south as the Vigten Islands.

Regarding the distribution of the "herring-food" in those parts of the sea which we traversed, I must say that the great mass of this slime, perhaps in consequence of steady northerly winds, seems to have been driven unusually far south, as in the open sea betwen Jan-Mayen and Norway there were for long distances only very small indications of its

existence, while the sea nearer the coast, especially in the most southerly portion examined by us, was swarming with "herring-food." In this we could only see a favorable sign of a possible return of the spring-herring fisheries; and later reports from the spring-herring district seem to confirm our expectations. Near Jan-Mayen we also observed, every now and then, below the above-mentioned sea-slime, great quantities of unusually large "herring-food," besides other animals peculiar to the Polar Sea.

The sea immediately surrounding Jan-Mayen seems both from a physical and biological point of view to resemble the Western Greenland Sea, and like this it is a genuine glacial sea, which all the year round is subject to the direct influence of the polar current, and even near the surface its temperature is very low, falling to 0° at the depth of a few fathoms. In such water no herring or codfish can live. The "herring-food" here chiefly serves as food for numberless sea-birds, and farther north, also, for the giant of the sea, the Greenland whale. The Northern Ocean, properly so-called, is, on the other hand, a partly temperate sea, through the warm Atlantic current, even as far as Spitzbergen. The waters of the Polar Sea only mingle with it occasionally, bringing with it some of the above-mentioned sea-slime, which here in warmer water begins to play the significant part to which we referred above, viz, forming the primary cause of success of one of the most important industries of our country, the salt-water fisheries.

VII.—AN ACCOUNT OF THE FISHERIES OF NORWAY IN 1877.

By M. Friele.*

A.—INTRODUCTION.

The fisheries of Norway are of considerable importance, whether studied in a general point of view or in the more limited sense of a source of prosperity to Norway alone. The methods employed, which approach nearer perfection every day, equally deserve our attention. They have, then, a triple interest—commercial, economical, and technical—which we trust will justify the publication of the present notices. Derived from the most competent sources, and resting upon very accurate official statistics, they will furnish to persons interested in the subject information which can be relied upon as perfectly exact and authentic.

B.—THE COD-FISHERY.

The different species of *Gadus*, or those constituting the family of the codfishes, give rise in Norway to fisheries of varying importance, but under the heading of the codfishery is generally understood the pursuit and capture of the true *Gadus morrhua* (skrei, cabillaud).

The inhabitants of Northern Scandinavia, from the most distant period, have applied themselves to this fishery; and at all times where it has been carried on, it has furnished the principal means of subsistence, and is to-day almost the only source of their income. This is all the more true as the cod-fishery is carried on to the greatest extent in the northern part of the country, where agriculture is little developed, and where the population from time immemorial has been accustomed to consider fishing its dominant occupation; in the north, in fact, agriculture is extremely unremunerative, and even in the south it furnishes but a secondary revenue. Fishing, too, is carried on in a season when the snow covers everything, when agriculture is necessarily at a standstill.

Fishing for cod has, then, a good claim to be considered the principal means of subsistence of the inhabitants; never in the memory of man has it failed for a single year upon the coast of Norway, though this has unfortunately been the case quite frequently with the spring herring. It has, of course, like everything in this world, undergone variations; in certain years, during certain periods, it has been less productive than ordinarily. This was the case in Söndmöre from 1714 to 1717, and in 1735, 1760, and 1775. At the latter date fishing failed almost entirely in the Loffoden Islands. In Finmark (Norwegian Lapland), too,

* Notices sur les Pêcheries de la Norwège. Impression à part du catalogue spécial de la Norwège à l'exposition universelle de 1878 à Paris. Translated by J. Paul Wilson.

in 1627, 1628, and 1629, the suffering was extreme, the cod having failed completely. There are also periodical variations in the richness of the yield. During a stormy winter tempests have succeeded in injuring the fisheries more or less, and at certain points the fishermen will tell you of periodical migrations of the cod from one bay or ledge to another, but tradition has never told us that the cod has at any period whatever ceased to visit the coasts of Norway; on the contrary, one may consider as assured the great fisheries of the Loffoden Islands and Söndmöre; this is more than can be said of the spring herring.

The cod is found all along the coast, but the best places for its capture are found in certain special regions. These, as before remarked, are principally the Loffoden Islands and Söndmöre, but the cod occur in other places in such quantity that they ought to be mentioned also. We may therefore mention the entire coast of East and West Finmark, where sometimes the fishing is as abundant as in the Loffoden Islands, especially when their favorite food, the capelan, (*Malotus arcticus*) occurs in abundance along the coast; several points off the coast of Helgeland, and the two prefectures of Drontheim, from Brönö to the mouth of the Gulf of Drontheim, on which points, however, the fishing is of less importance, a large part of the population preferring the Loffoden Islands; and finally the coast of Nordmöre and Romsdal. Formerly, the cod was sought more to the south, even beyond the coast of Jaederen, and especially toward Skudesnaes, as far as Bergen, but the product of this fishery has diminished gradually since 1796, and it may be said to have entirely ceased since the return of the spring herring; it appears, however, to have increased again since 1869, the epoch when the spring herring again diminished.

At the Loffoden Islands fishing is not generally in operation until the beginning of February.

The cod, having passed the extremity of the group of the Loffoden Islands, press in innumerable legions between Moskenaes and Vaerö, or between Vaerö and Röst, to get into the Vestfjord. They follow this fjord until they meet the coast of Eastern Loffoden, and there fishing is most profitable. Fishing, however, is prosecuted also at the same time more to the west among these islands, where the fish shows itself before reaching the coast, that is, Eastern Loffoden. After this, fishing continues between Moskenaes and the most retired point of Eastern Loffoden until the 14th of April, the period when all the fish should be hung up for drying, and when the engagements of the hired fishermen generally expire. In general, after this date the fishermen return home, but in Western Loffoden even up to the end of the month, they carry on a subsidiary fishery during the retreat of the fish. The product is, however, very meager.

As soon as the Loffoden fisheries close, and, for several years back, before they have entirely ceased, a great part of the fishermen betake themselves to Western Finmark, where at this time the fishing generally commences. In the fisheries of Finmark we must distinguish

between the "*godtfiskeri*," which takes place early in the spawning season, and the "*loddefiskeri*," or capelan fishing, which occurs later. Although in Finmark also the cod seek the coast every year, especially after spawning time, the fisheries are very uncertain, and have often in late years caused losses to buyers and to the fishermen who have come from a distance.

The extent of the coast of Finland, where the fish come to seek the shores, is so great, and the weather generally so tempestuous, that it is difficult for the fishermen to arrive at the proper time at the most advantageous localities, especially as precisely at this portion of the year the means of communication are very defective. The capelan, too, whose presence is indispensable to success, is very capricious in its proceedings; it appears sometimes at one point, sometimes at another, and sometimes not at all. It follows that the fisheries of Finmark, as far as outsiders are concerned, are generally of a doubtful character, sometimes very lucrative, sometimes quite the opposite, while the home fishermen can always work them to advantage. The principal banks (*fiskevaer*) are Bredvig, Midfjord, Ingö, Gjaesvaer, Hjelmesö, Havösund, Horningsvaag, and Kjeldvig.

The same instinct which drives these incalculable masses of fish toward the coasts of the north to spawn, sends also to the coast of Söndmöre all the right wing of the same army. From the end of January or the beginning of February the cod commence to rush in by three or four openings (Vanelvsgab, Bredsundsdyb, Boddyb, Griphölen); and it is claimed that this movement continues until the 12th of March. Here, as in the Loffoden Islands, fishing closes toward the middle of April. These fisheries have always been very important, and particular attention has been paid to their development in the last half century; the inhabitants of the district all take part in it, and the benefits have not ceased to increase since Aalesund has become a fair and sure market for the products. Even here, howmuchsoever assured the product of the fisheries of Söndmöre may be, there are great irregularities of distribution. As an illustration, the fishery of Borgund, after passing through the different extremes of great richness and extreme poverty, disappeared almost entirely in 1830; and it is only in the last two or three years that it has shown signs of returning animation; in 1877 the fishing there was pre-eminently abundant.

The yield of cod in 1877 was the most abundant of which we have any record. According to official reports it amounted to—

	Cod.
In the Loffoden Islands	29,500,000
In other fisheries of the north	4,500,000
At Finmark	17,500,000
And at Söndmöre, Römsdal, Nordmöre	8,500,000
Adding the yield of the various little fisheries along the coast, estimated at	7,500,000
We have in all	70,000,000

The cod, including liver and roe, or just as it is before dressing, may be estimated at 45 centimes (9.72 cents), and the catch of this fish represented in 1877 a value of about 31,500,000 francs* ($6,300,000) on the fishing-grounds.

The returns from the different localities were as follows:

In 1873, 49,500,000 cod, worth	$4,240,000
In 1874, 47,500,000 cod, worth	4,060,000
In 1875, 53,000,000 cod, worth	4,300,000
In 1876, 38,000,000 cod, worth	3,600,000

In 1877, 4,567 boats, manned by 21,287 men, took part in the fisheries of the Loffoden Islands. The average gain of each fisherman during the season may be valued at $120, or about 96 cents a day. The number of boats employed was—

In 1876	4,911
In 1875	3,905
In 1874	3,966
In 1873	3,713

The principal cause of the increase of the vessels employed since 1873 is doubtless the disappearance of the great herring of the North, those employed therein now seeking their living in the Loffoden fisheries.

The codfishing of the districts of Nordmöre, Romsdal, and Söndmöre is carried on by about 2,500 boats, and that of Finmark by 4,000 boats. The principal fishing-banks of the Loffoden Isles are Hennivgsvaer, Hopen, Svolvaer, Kabelvog, Stamsund, Balstad, Stene, Ure, Vaerö, and Röst.

1. Apparatus used in the cod-fishery.

The apparatus employed is the same in every country, and is essentially of four kinds: hand-lines, trawl-lines (palancres) or bottom-lines, nets, and seines or bottom-nets; and the fishermen themselves are classed according to the nature of their implements. Very often, however, a boat is provided with both lines and trawls (palancres) or trawls and nets.†

---

* In reducing francs to dollars, the value of the former has been taken at 20 cents; it really is worth only 19.45 cents, which involves an error of a little more than half of one per cent.—Translator.

† According to Mr. Hermann Baars, *Die Fischerei Industrie Norwegens*, Bergen, 1873, the cod-fishery is prosecuted at the Loffoden Islands in three different ways: with hand-lines, with trawls, and with nets.

Hand-lines, as a general thing, are used only by the poorest fishermen, who are without the means to obtain the more expensive trawls and nets. The hand-lines usually yield about fifty fish per day, but sometimes as many as one hundred or one hundred and twenty. For hand-lines, fresh or salted bait is made use of. If these are not to be had, then a portion of the cod or its roe is employed.

A vessel fitted out for trawl-fishing is provided with at least six gangs, or twenty-four lines, each line carrying one hundred and twenty hooks, which are fastened to

a. The hand-line.—The hand-line is the least complicated of all the apparatus. It can be used everywhere as soon as the fish appears and establishes itself on the banks. Herring, when procurable, is used for bait; otherwise, simply roe. The best of all baits, however, is the capelan. In the Söndmöre they fish also with the line, and often without bait, by putting above the hooks a little tin fish, intended to attract the cod, which they catch, when it tries to bite, by raising and lowering the hook.

Fishing with the simple line is gradually disappearing before the improved methods, but it is carried on in the following manner: The boats, manned in the Loffoden Islands by from three to five men, in the Söndmöre by about eight, betake themselves to the open sea, provided that the weather offers no obstacle, and begin by seeking the fish upon the banks at a depth of 30 to 40 fathoms, and at distances of six miles or more, sometimes in the Söndmöre of 20 to 25 miles. The product of this fishing is very variable, the fish not always biting even when on the banks. The fatter it is the less likely it is to bite; and experience has shown that line-fishing is especially productive in years when the fish is thin and toward the end of the season. In the Loffoden Isles the daily catch of a boat with five men is estimated at 250 fish, but it sometimes amounts to 500, which is all that the boat will ordinarily hold. In the Söndmöre, where the boats are manned by eight men, the average daily catch is rated at from 180 to 250 fish, but it sometimes attains to 500.

b. The palancre or *trawl-line.*—The palancre or trawl-line is an im-

---

fine lines of hemp or cotton, 16 or 20 inches long, and 6 or 8 feet apart. The bait used is the same as for the hand-lines.

According to the number of the crew and the local circumstances, the trawls are set in lengths of 500 to 2,400 hooks, and usually in the afternoon. When the fish swim at some distance above the bottom, the trawls are kept at the proper height by means of glass floats. The trawls are taken up the next morning.

When the fish are sufficiently near the coast to make it possible to reach the trawls quickly, they are sometimes taken up on the same day. The yield of the trawl varies. On the average, however, it may be estimated at 15 or 20 fish to the line of 120 hooks.

The fatter the fish the less it is attracted by the bait; and during the spawning season it scarcely ever takes the hook at all. For this reason the well-to-do fisherman is usually provided with nets as well as trawls.

The vessels fitted out for the use of the gill-nets generally carry sixty or seventy of these, of a length varying from ten to twenty fathoms, and twenty-five to sixty meshes wide, which are from three to three and a half inches between the knots. These nets are held upright in the water by means of floats of hollow glass, the invention of merchant Christopher Faye, of Bergen. Sometimes, however, wood or cork is used. The glass floats are almost exclusively in use in all the Loffoden Islands. From sixteen to twenty nets are generally fastened together and set in the sea in the afternoon in one length, care being taken to avoid their being mixed up with the trawls and hand-lines. When the weather permits the whole of these are taken up the next morning. A yield of four or five hundred cod is considered satisfactory. If it exceeds this to the number of six to eight hundred fish, the fisherman is obliged to allow a portion of the nets to remain undisturbed until afternoon, as the boats will seldom carry the larger number with the nets and equipment (p. 10).—TRANSLATOR.

provement of the simple hand-line. It has for a long time been almost the only engine employed, and now it may safely be said that nearly half of the vessels engaged in cod-fishing are provided with this alone.

In fishing by this method the Loffoden boats are equipped with six men and a cabin-boy; in Söndmöre, as in other cases, with eight men. The complete equipment, without counting that reserved for contingencies, consists of six gangs (of four lines each), or 24 lines in all, each line provided with 120 hooks at a distance of four to six feet apart, and mounted upon cords of hemp or cotton 15 to 20 inches long. The bait employed is the herring when on hand; but this is kept especially for night fishing. They employ also, and above all for day fishing, the roe remaining in the fish after spawning, or else ordinary roe.

A setting consists of from 500 to 2,500 hooks, according to the abundance of the fish; and at certain fixed hours the fishermen proceed to set their trawls at very variable distances, from 7 to 12 miles at the Loffoden Islands, and 18 to 25 in Söndmöre. The trawls are set in the water according to the position of the cod, sometimes all on the bottom, sometimes just under water in a depth of 40 to 60 fathoms. They are hauled up in the morning, a duty which generally falls upon the captain of the vessel, assisted by some one to lift the fish into the boat and detach them from the hooks. The product is variable; and it may be said of this method, as of simple line-fishing, that the fish do not bite always equally. Trawling succeeds best in years when the fish are very fat, as also at the commencement of the season before the fish have had time to become thin, and during the spawning period, when they do not bite at all. At these times fishermen rich enough to possess both trawls and nets employ the latter. When the fish do bite the catch may be very productive, and each gang (bac), containing 480 hooks, may yield as much as 120 fish, which would amount to 720 cod for a vessel of six gangs, but in the event of so large a catch the boat is so heavily laden that during rough weather it is found necessary to clean the cod on the way and throw away the heads and entrails, keeping only the marketable products—the body, liver, and roe. This, however, is an exceptional case; two hundred and eighty to three hundred and fifty cod to a boat (40 to 50 a gang) is considered a good average.

Besides the night settings, day-lines are sometimes used when the fish bite well. These are generally put down just under water, but produce less than in the night, and can only be employed where the banks are sufficiently near the coast.

c. The gill-net is an engine of recent introduction, and as its use does not extend back beyond 1685, it took a long time to come into general eral use, though it is quite indispensable when the cod does not bite.

A boat when complete carries six men and a boy. Each man has generally 10 nets, making 60 nets to a boat. These nets are from 18 to 20 fathoms long, 10 to 13 feet deep (25 to 60 meshes), and the meshes are from 2.80 to 3.20 inches square. Formerly they were maintained verti-

cally in the water by means of floats or buoys of cork, juniper, or willow, but lately, and especially in Loffoden, they use glass balls, invented some thirty years ago, covered with knotted, tarred cord as a protection. These balls or floats are attached to the nets and replace to great advantage the old buoys, which failed to prevent the nets from settling on the bottom. The nets are joined together in lines of sixteen to twenty, forming thus fences or walls of 300 to 400 fathoms in length and 10 to 12 feet in height. The apparatus is dropped in the water in the evening simultaneously by all the fishermen, and, according to the position of the fish, they extend the nets to the bottom or above it. The distance from the coast varies very much; it is sometimes 5 or 6 miles; in Western Loffoden it is 10, and in Söndmöre 20 to 30 miles. It is evident that the nets should not be set at the same place as the trawls. Every morning, when the weather permits, the nets are raised; and if everything is favorable 600 cod to a boat may be gathered in, though they will not take the hook, and the trawl cannot be used. This is all that a boat can carry without too much labor when the weather is stormy. If the catch be still more prolific, the raising of some of the nets is deferred for a time. A haul of 350 cod per boat in a night is considered satisfactory and a good average.

d. Seines or *bottom-nets.*—These engines have been introduced in later years with success in the fisheries of the Loffoden Islands. The seines are formed by nets joined together by an ingenious system of cordage, fastened at the bottom by anchors, and at the surface by boats. At a given signal, and by the assistance of a tackle and cords, the lower edge of the seine may be raised, thus encircling the part of the surface comprised between the boats, and imprisoning all the cod contained therein. For one seine 30 to 40 men and 6 to 8 boats are generally required.

2. The daily fishing.

In the heart of winter, in the dark and stormy days of January, early or late, according to the length of the route to be traversed, the fishermen set out in their covered boats, so as to be at their destination as soon as the season commences. To the more southern fisheries from Söndmöre to the prefecture of North Drontheim, the course is never very long—at the most 45 to 55 miles—the fishermen coming from the bays of Northern Söndmöre. But it is quite different as regards the Loffoden fisheries, where the route for most of the fishermen is at least 250 to 350 miles, whether at open sea or through the gulfs, where the sea is often very rough; and at the last part of the voyage, the passage of the Vestfjord, the navigation is far from being good. These thousands of vessels, however, many having a crew of but two or three men apiece, generally arrive in safety at their destination.

Upon arrival the fishermen, both those working on their own account and such as are hired, proceed to the cabins rented to them by the proprietor of the soil, and there install themselves for the winter. These

cabins are relatively quite comfortable, and the food, fresh fish and liver, with coffee, is comparatively good. Several crews are often established in the same cabin. The air is not always very pure, but fishermen are not hard to please.

The trawls as well as the nets are thrown over board in the afternoon; all the apparatus at one fishery being set simultaneously to prevent it from becoming tangled, though sometimes this is unavoidable, owing to the tempests and tides.

The next day, at dawn, if the bad weather does not make it impossible, all go back again, at a given signal, to raise the apparatus. The trawl-fishermen take the fish off the hooks at once, but those having nets wait to empty and clean them until they have regained the land, except in Söndmöre, where the nets are immediately dropped again in the water. The fish are never killed on the spot, but as soon as the engines are taken from the water the fishermen return to the land and the fish are dressed, the catcher reserving for his own use the liver and roe. The cod is sold to the boats of speculators, of which there are always several in each fishery, and which transform it into *klipfisch*, or salt fish (*morue plate*), or else the fishermen cure them on their own account, to make *stockfish* or dried fish (*morue en bâton*). The entrails are thrown away, and the heads are sold to fish-guano manufacturers, or reserved as food for the domestic animals. The tongues and bladders are sometimes taken out and salted for sale. The fish cleaned and hung up, the fishermen arrange their implements for a new cast, proceed to the proper point and throw over the trawls and nets. Their day's work is then finished.

The hand-line fisherman remains on the water all day; in the evening he dresses his fish and sells it, generally fresh, to the salters.

This work is, unfortunately, too frequently interrupted; sometimes the storm hinders the fisherman from putting his implements in the water, and his time is then lost; and sometimes during several days it may prevent him from raising them, and expose him to the danger of losing at the same time his apparatus and catch of fish. The misfortunes, however, sometimes become frightful, and hundreds of lives become destroyed when one of those sudden storms comes up which seem to be the lot of such regions. Those who get off with the loss of their machinery esteem themselves happy if, after having been tossed about on the deep and undergoing incredible fatigue, they arrive finally on land alive, but famished and paralyzed with cold. It is not rare that in such a storm boats have been thrown from one coast to the other of the Vestfjord. Cases are mentioned where inhabitants of Söndmöre have been driven in this way to Scotland. The annals of the country speak of many winters when a multitude of fishermen have lost their lives. To mention one year only out of each of the last three centuries: in 1634, the year when the island of Nordstrand, in Slesvig, disappeared, and when the church of Röst was blown over by the tempest; in 1743, when Sönd-

möre lost in a single day 174 fishermen; but, above all, the 11th of March, 1821—fatal Monday—when hundreds of lives were lost simultaneously all along the coast of Norway. The parish of Haram lost on this day nearly 300 men. In April, 1875, a similar catastrophe took place in Finmark, 100 boats perishing in one day, with 200 to 300 fishermen, who, having set out in the morning under fair auspices, were soon after assailed by a northeast storm and a terrible fall of snow.

In Söndmöre and Ramsdal fishing is carried on a little differently. The peasants are nearly all fishermen, but, besides this, the merchants of the city and country fit out one or more vessels. All require workmen to aid them, and it is necessary to seek them in the most distant fjords and valleys, where the peasant does not live ordinarily by fishing. Lately the number of vessels equipped has increased so much that it has become impossible to find the necessary hands.

The Söndmöre fisherman sets out toward two o'clock in the morning. The vessels, manned by seven or eight men, are provided with nets, trawls, or hand-lines. The latter are employed, as before stated, often without bait, but provided with a tin fish.

The trawl and net are used here as in the Loffoden Isles, always with this difference, however, that the route being much longer, the apparatus is immediately returned to the water. If the weather is fine enough the fishermen remain till it is time to draw up the second cast, for the boats are large enough to carry the product of two successive hauls. A catch of 350 to 450 cod is considered good. The fish, turned over to the women on reaching land, are generally prepared into *klipfisch* or salt fish.

The product of this fishery has never been as abundant as in the Loffoden Islands, and they consider the catch good when the winter campaign reaches 5,000 to 6,000 cod to a vessel. This fish is generally large, weighing about 1,100 grams (36.6 ounces). Manufactured, as it is, into dried fish, it brings in recent years a very high price; as, furthermore, the Söndmöre fisherman can devote himself to this fishery without leaving his home, cod-fishing in Söndmöre is generally considered a very lucrative occupation.

3. Quality of the cod.

We have seen that the largest and fattest cod do not bite at the hook, and must be sought after with gill-nets. It follows that the latter implement furnishes a very superior article of merchandise. It requires sometimes but 210 cod caught in a net against 360 taken with the hook to furnish a hectoliter (about $26\frac{1}{2}$ gallons) of liver, and $1\frac{7}{8}$ to 2 hectoliters of liver taken from the former against $2\frac{1}{4}$ to $2\frac{1}{2}$ of the latter, to furnish a hectoliter of oil. In unproductive years, and toward the end of the season, 500 to 600 cod are sometimes required for a hectoliter of liver; the livers taken at this time are relatively still less rich in oil.

When a fish has passed more than three days in a net it can no longer be made into *klipfisch;* up to five days the livers may still be

used, and in case of necessity the fish may be converted into stockfish; after five days, however, the fish are good for nothing, and they are obliged to throw them in the sea. In the Doggerbank fisheries, and those of Iceland and Newfoundland, where they do not use nets, and where the fish is caught alive, they kill it immediately and thus obtain a finer and whiter article. With us in Norway the fish is never killed at the moment when it is drawn from the water, and the blood accumulating in the entrails is always detrimental to its appearance. When the fisherman has reached land with his fish, he prepares it; that is, he does not sell it just as caught, which is done sometimes. The liver, roe, and head are taken from it; the liver is put aside, but the roe is salted immediately; the heads (as stated) are thrown to one side, and the entrails as well. The cod is then made either into salt fish (*klipfisch*), or perhaps stockfish (*stockfisch*). Its manufacture into *klipfisch* was introduced into Christiansund by Englishmen toward the end of the eighteenth century.

4. Preparation of the cod.

*a. Salted fish** (*klipfisch*) or *flat cod.*—The cod is delivered to the buyers, who have to split and dry it. In Loffoden these buyers are generally coasters, sometimes speculating for merchants, or, what is rarer, trading on their own account. In Nördmöre, Romsdal, and Söndmöre, where all the fish are converted into *klipfisch*, the fishermen sometimes deliver the fish fresh to the neighboring cities, as Aalesund and Christiansund, so advantageously situated for this purpose, or to the country merchants, but often the fisherman prepares them himself. The amount of salt employed is generally $4\frac{1}{2}$ hectoliters ($12\frac{3}{4}$ bushels) to a thousand cod. The best salt is that of Liverpool, used generally in the fisheries of Scotland, Iceland, Newfoundland, and Labrador. Cadiz salt is good, too, and is generally employed in Norway. The gray salt of Western France (Croisic Vannes, St. Martin, de Ré) preserves the fish very well without salting them too much, but requires careful washings to give to the fish a fine appearance. With us the salting is done principally in the holds of the vessels, often in the store-houses, and sometimes on the shore, so that the fish may become soaked in the brine; in the latter event it becomes salted more effectually, but it is necessary in this case to press more strongly at the time of drying. As soon as the weather permits, the cod is washed; that is, all the superfluous brine is removed, and the fish stretched upon the rocks, where the fresh land-breeze and the sun dry them. Much care is required to produce a good article, and when snow or rain falls they must be gathered together as quickly as possible in heaps. In this way the outside fishes only suffer. When the weather becomes clear they again stretch the fish upon the rocks, and if the sun darts upon them they must be turned over and over continually, that they may not burn. The fish deteriorates when the sun's

* This is what is known in Massachusetts as Kench-cured fish.—TRANSLATOR.

rays are too strong, or when exposed for too long a time. Finally, after weeks of work, of watching, and of patience the cod is dried and becomes "dried fish" (*klipfisch*). Generally two pounds of dressed fish are necessary to make one pound of *klipfisch*. Thin fish also lose more than fat. The *klipfisch* obtained weighs on an average from 1¾ pounds to 2¼.

b. Rundfisch or *stockfish* (*morue en bâton*).—This is generally prepared by fishermen on their own account; speculators, however, are beginning to take an increasing interest in it. This preparation is scarcely made except in the Loffoden Islands and in Finmark. The fish not salable for *klipfisch* are usually employed for this purpose. The preparation of each species depends very much on the price at foreign places, or rather at Bergen, of which the fishermen are regularly informed.

As soon as the head and entrails are removed, the cod are tied together by the tail, two by two, and placed thus a-horseback, so to say, or on a bar resting at each end on supports. The work is then done, for the wind and sun attend to the rest.

The fishermen go away leaving the fisheries and their establishments, after having generally engaged a man, at a cost of 60 cents a crew per day, to watch the fish and to replace upon the dryers those knocked off by the wind or by birds of prey. The fish is thus left to itself until the 12th of June, before which no one can take away his *rundfisch*. It is very rarely that the owners of the fish have to complain, and police ordinances have assisted in increasing the security. It is rare, too, in the Loffoden Islands that the fish spoils, because generally in the spring north winds and dry weather prevail there. In Finmark, on the contrary, it happens frequently that the weather is moist, and the article is rarely so good as that coming from the Loffoden Islands. The *rundfisch* is generally reckoned as weighing about 720 grams (1½ pounds).

C. Morue salée, or salt cod (*Laberdan*).—This article, so much used formerly, has now nearly disappeared before the manufacture of *klipfisch*. It is still prepared in Finmark by the Russians during the very hot weather, when the other methods of preparation are inapplicable. The cod is given to them in exchange for other objects of consumption, principally flour.

5. Preparation of the oil.

Formerly the extraction of the oil was performed by the fishermen themselves, and only after the fishing was ended, but now the liver itself constitutes an article of merchandise, being sold by the fishermen to dealers who have the oil extracted.

As the cod is cleaned the liver is placed in water-tight casks, where it passes several months, until it can be boiled. Before proceeding with the boiling, all the oil is drawn off that will come easily, and this, under the name of pale oil (*huile pâle*), is used principally in medicine. The oil procured while the livers are fresh is naturally the purest and best (*huile médicinale naturelle*).

After taking away the natural oil the livers are put to cook, and they extract successively the "brown pale oil" (*huile brune pâle*), and the "brown oil" (*huile brune*). The latter is an inferior product, employed principally by tanners, and is shipped away in oak or fir casks. The residuum is employed as manure, and is much sought after.

The extraction of the medicinal oil is carried on by separate manufactories. They use always fresh livers, carefully washed and dried. They are placed in tin-plate boxes with double walls, with a circulation of steam or warm water between. The oil is then drawn off and filtered, as fast as it is produced, through paper filters, then shipped away in tin cans or oak barrels. The residuum, by further cooking, furnishes common oil (*huile brune ou verte*), which is likewise used in the arts.

6. Roe.

A third product of the cod-fisheries is the roe, which, in the eighteenth century, was used for the first time as bait for sardine-fishing upon the coasts of France and Northern Spain. The roe is prepared, to some extent, by the fishermen themselves, but it is often sold fresh. Part is used at the place of capture as bait for the cod; the rest is salted for exportation. For salting the roe the gray salt from France was formerly used, but they now employ white salt from Cadiz. The salting is done in barrels with holes bored in them to permit the brine to run out, so as to leave the roe always comparatively dry. The best roe is that gathered at the beginning of winter. Later it becomes less and less good, and after the spawning season there remains only the empty ovary. The high price of the roe in France has been the cause of their seeking to replace it by substitutes. Dr. Morvan has succeeded in part by the introduction of the African locust preserved in salt, as bait. But as these locusts are only procurable when there has been a grand invasion of them into Algeria, this product was not one that could be relied upon, and, besides, its price was not much lower than that of the Norwegian roe. The same Dr. Morvan and his associate, Mr. Delasalle, an old sea officer, had more success with the roe called Douarnenez; they manufactured it with the remains of meat and fish as well as cakes of an American ground-nut (*Arachide*) thoroughly mixed together. The product was compounded with the Norwegian roe in the proportion of 3 to 1, which caused a sensible saving, the price of the new mixture being 30 to 35 francs against 60. The success, however, of this preparation, has, it is said, been but temporary, and the diminution in value of the Norwegian roes in 1877, due to the abundance of the article, seems to have diminished its use.

7. Other species of the genus Gadus.

It is proper to add here some details upon other fisheries which form an important element of the work on our coasts, and which contribute toward maintaining the markets of the interior and exterior. Hitherto

we have only spoken of the great annual fishery of the *skrei*, or true cod, which takes place nearly simultaneously upon all points of the coast during the first months of the year. This is the sea-cod, properly called, that is, the adult fish, which at certain periods seeks the coast to spawn there.

But outside of this fishery there is maintained, through the entire year, in the Loffoden Islands, and one may say the whole coast from Eastern Finmark to Söndmöre, a considerable fishery of the other species of the genus *Gadus*, which, though far behind that of the *skrei*, occupies a number of hands and is a notable source of revenue for some localities.

Let us consider first the summer-cod fisheries. The shore-cod (*Gadus morrhua*), like the herring, presents, in different periods and localities, different forms. It is impossible to define exactly these forms, but they are simply varieties of the cod which has not yet attained its maturity, or sometimes modifications connected with the nature of the bottom where the fish live. Fishermen, as well as merchants, embrace them under the general denomination of "cod" (*torsk*), or little cod; it is only in the classification of the merchandise for sale in bulk that different names are given, which we will indicate further on. The pursuit of this fish takes place in various localities during the whole summer, principally with the simple hand-line, but also with the bottom-line. The population, in many places, passes nearly the whole day on the sea when the weather permits it, and catches, according to the season, all the varieties of fish which approach the coast, above all cod, which is treated in different ways.

In the districts of Senjen, Salten, and Helgeland all the summer cod are hung up with the other cod, though sometimes they are split to the tail before being suspended; in this case they take the name of *rotscheer* (*rodskjaer*), or they are left round, when they are known as "*tittlings*." It is not the cod only which is sold under these denominations; all the summer fish receive the same names; so we have cod, cusk, or haddock made into *rodskjaer* or *tittling*.

In Namdal, and further to the south, besides the desiccation of the fish upon rods or horizontal bars, recourse is also had to drying upon the rocks. The fish is generally cut open, but sometimes left whole, and the process of drying is left to the sun and wind. It is turned now and then with the hand, or by means of a rake, like hay. This method is evidently very simple, and saves a considerable expense for the bars and scaffolding, but it is little to be recommended, and ought even to be prohibited, for the fish not only wrinkles and becomes twisted, presenting a bad appearance, but it often spoils, either on account of the too ardent rays of the sun, which cook it to a certain extent upon the rocks, or by rainy weather, which hinders thorough drying out. This method, consequently, produces a far less valuable article of merchandise than that of laying out on scaffolding or flakes.

Besides the real cod, many fish belonging to the species of the same family are caught every summer and autumn upon the west coast, though their importance would be much greater if prosecuted in a more rational manner, and the product satisfactorily utilized.

The principal species coming under this head is the green cod, or *gade-sey*, or pollack (*Gadus virens*). When less than a year old the *sey* bears the name of "*mort*," and is caught upon the west coast of Norway, and, above all, between Stavanger and Cape Stat, in innumerable quantities.

The pollack-fishing is carried on in three different ways:

1. By the line. The fish is attracted to the vicinity of the hook by throwing in the water a bait composed of mussels and crabs cut up very fine. While the fish is amusing itself in picking up these bits it perceives the baited hook, and bites at it in preference. This method is especially characteristic of the vicinity of Bergen.

2. By trailing behind a boat one or two lines with baited hooks.

3. But the special and habitual manner of catching the *mort* consists in placing upon the shoal bottom (it is there always that this method is prosecuted) a round-bottomed net in the form of a bag attached by the upper part to a large hoop of 2 to 3 yards in diameter. This net or *glip* being let down by the aid of a pulley, they throw above it bait cut up fine, and raise the bag by the pulley when a swarm of *mort* have been attracted to it. The product of this fishery is very variable, but sometimes twenty-five and more are caught in a single cast. *Mort* is eaten in the country, fresh or salt.

At the age of one, two, and three years, the *sey* or pollack takes the name of *pale*, and furnishes an esteemed article of food. Its liver gives good oil. It is at the age of four years that the fish becomes *sey gris* (*Gråsey*, in Sweden), and takes its full importance in the fisheries. It is met on the whole coast, but in schools less considerable than the true cod. It is a very voracious fish, and consumes an enormous quantity of herring, especially when these are in the form of fry.

The *sey* is caught especially in Eastern Finmark, Nordland, Söndmöre, the fiords of Bergen and Ryfylke; and is taken in every possible fashion. It is very easily caught, sometimes being captured from the shore with hooks. It is also taken by jerking up quickly a baited line. Finally, and above all, it is caught with seines, especially when it is enjoying itself among swarms of herring newly hatched. An ingenious process for catching the pollack with seines was invented in Söndmöre, and is employed in Finmark and Nordland as well. This fish, in fact, always seeks the bottom as soon as it perceives the net. It is on a larger scale the same process as that employed for taking the mort, or young pollack. A large, square net is let down to the bottom, and its four corners attached by cords to as many boats. When the *sey* comes above the net, as soon as it perceives it, it makes for the bottom, and

the net is then raised by the crews of the four boats. This method is very profitable, and can be prosecuted on a large scale.

The liver of the *sey* is worth a great deal; in midsummer one hecto liter ($26\frac{1}{2}$ gallons) per 200 fish may be obtained.

In Nordland, Finmark, and farther to the south the *sey* is cut open and dried by the same process as the *rotscheer*. The *sey*, when cut open and dried, is called peasant sey (*sey de paysan*); that caught and prepared in the south is more sought after than that of Nordland and Finmark. Attempts have been made to prepare the *sey* into *klipfisch*, but with little success, owing to its dark color. Perhaps if the fish were killed as soon as taken, washed thoroughly, and submitted to compression, a better product would be obtained.

In commerce the *sey* bears the name of large *sey*, medium *sey*, and little *sey*. The first two are exported especially to the east, to Sweden, and to Russian Finland, principally by way of Bergen, but also through the cities of Finmarken, of Aalesund, and of Christiansund. The little *sey* purchased in the markets of Nordland is sold again, principally at Levanger, to the dealers of Jemteland (Northern Sweden), and is distributed thence throughout all the north of Sweden; it is also exported by the same cities as the great *sey*.

By the side of the pollack may be placed the ling, conger, or molve (*Gadus molva*). It is sought after only in summer, and between Nordland and Cape Stat, and even more to the south in the exterior islands of Söndfjord toward Bremanger and Kinn. This fishery is carried on for the most part upon the banks or shoals with lines or trawls, baited with herring, *mort*, or little *sey*. The Swedish fishermen also take part in this at a certain distance from the coast.

To this list we must also add the brosme or cusk (*Gadus brosmius vulgaris*, Cuv.). It is taken in the same manner as the molve or ling. From Bergen to Finmark, like the molve, it is converted into *rotscheer* or titt-ling, but is less profitable. *Klipfisch* is another product of it. We may finally mention also the haddock (*hyse*, *kolje*, or *Gadus æglefinus*), the *Gadus pollachius* (*lyr*), and the merlin.

The services of steam and the telegraph have been largely drawn upon in the interest of the cod fisheries. For a long time regular and frequent communication by steamer has existed between the places of the south and the Loffoden Islands, which facilitates greatly the correspondence, the transmissions of money, and the transport of fishermen. The hired fishermen often prefer to take the steamboat, so as to arrive at the day agreed upon. The continuation of the lines of boats to Vadsö has produced the most favorable results for the Finmark fisheries, the fishermen of the Loffoden Islands being in the habit of using these steamers to go to Finmark to finish their season. As to the telegraph, its network embraces all the Loffoden fisheries, and the greater part of those of Finmark, which thus find themselves put into communication with native and foreign telegraphic stations.

8. THE CODFISH TRADE.

Bergen is the principal market for the cod. The arrivals of salt and dried fish take place at two fixed periods, or in two distinct shipments. The first shipment reaches Bergen in the end of May. It comprises fish-oil, roe, autumn *tittlings*, and autumn *rotscheers*. The second shipment, which arrives at the end of July or the beginning of August, brings *klipfisch* (morue plate), *rundfisch* (*stockfisch*), and spring *rotscheers*, and such oil and roe as has not been able to leave by the first convoy.

a. The klipfisch or salted cod trade.—The time of shipment of the *klipfisch* (kench-fish) varies according to localities. In Söndmöre it is ready to be shipped from the city of Aalesund in the course of May; vessels take it thence for transportation to Spain and Portugal. Toward the same epoch the fisheries situated at the south of Cape Stat carry their products to Bergen, and those of Romsdal and Nordmore bring theirs to Molde and Christiansund. As to the Loffoden and Finmark *klipfisch*, it is sent to Drontheim, Christiansund, Aalesund, and Bergen, and exporters re-export it to Spain, Portugal, Italy, Cuba, and South America. Christiansund is the principal market of *klipfisch*. For shipment to Europe, they pile up the *klipfisch* in the hold of vessels; for countries beyond the sea it is pressed into wooden boxes, which permits its preservation for several years. Molve (ling), brosme (cusk), and haddock are prepared the same, whether designed for Spain or Scotland, and weigh as follows: Molve (ling), made into *klipfisch*, about 2¼ pounds, sometimes 7 to 11 pounds; brosme (cusk), made into *klipfisch*, about 2¼ pounds; haddock, made into *klipfisch*, about ¾ pound.

b. Tittling.—Autumn cod, dried and transformed into *rundfisch*, are divided into four classes:

1. Autumn *rundfisch*, weighing about 800 grams (26 ounces).
2. Holland *tittling*, weighing about 320 grams (10 ounces).
3. Bremen *tittling*, weighing about 170 grams (5½ ounces).
4. Ordinary *tittling*, comprising that which has not been placed in the first three categories.

c. Rotscheer.—This is divided into—

1. Holland *zartfisch*, about 900 grams (29 ounces), for Sweden, Denmark, and Holland.
2. *Wackerfisch*, about 530 grams (18 ounces), for Denmark, Holland, and Italy.
3. *Hökerfisch*, of 210 grams (6¾ ounces), for Holland and Germany.
4. Winter *Rotscheer*, which is frequently frozen and shipped to Sweden, Denmark, and Germany.

Molves, or ling, are divided into—

White or diaphanous molves, 2¼ to 4½ pounds, for Holland.

Great fine ling, about 4½ pounds.. } For Holland, Sweden, and Germany.
Small fine ling, of about 2½ pounds }

Common molve, for Sweden and Italy.

The *seys*, or pollack, embrace three classes:

Large *seys*, of about 29 ounces	For Sweden and Finland, and a little for South Italy.
Medium *seys*, of about 17 ounces..	
Little *seys*, of about 10 ounces	

Brosmes, or cusk, are separated into—

White brosmes, weighing about 13 ounces, and common brosmes shipped especially to Holland.

d. Stockfisch (*morue en bâton*).—The *stockfisch* is divided as follows:

1. Great lob, weighing about 4½ pounds.	For Holland, Germany, Belgium, and Italy.
2. *Rundfisch*, Bremen assortment, 2½ pounds	
3. *Rundfisch*, Dutch assortment, 20 to 23 ounces	
4. *Rundfisch*, Italian assortment or mixed, about 29 ounces	For Italy especially.
5. *Rundfisch*, not classified	

The *rundfisch*, like the *rotscheer*, bears transportation to the most remote countries; every year some ling or molves are sent as far as China.

Finmark *rundfisch* is for the most part exported from the ports of Tromsö, Hammerfest, Vardö, and Vadsö for the Mediterranean ports.

e. Oils.—As remarked before, the oils are classified according to their quality. The barrels are ordinarily oak, but sometimes fir or pine. A barrel of oil contains 116 to 118 liters (about 30 to 31 gallons), and weighs net about 100 kilograms (220 pounds). Before being exported the oil is carefully clarified and verified by the sworn trier. The oils are shipped to all the countries of Europe, principally to Holland, Belgium, and Germany; France also takes several thousands of barrels.

f. Roe.—The roe, too, is sorted by a sworn sorter into two grades. To prepare the roe for exportation, the barrels in which it has been kept since first being gathered are emptied and the roe is put in layers in others, taking care to put a little salt between each layer. They let the barrels stand five days before putting the head on, to give the roe time enough to settle and become closely packed. Holes are generally bored in these barrels so as to produce "dry roe." Some, however, are not pierced, so that the brine may remain in; this last treatment produces pickled roe. The barrel of roe weighs 250 to 275 pounds gross. The net weight does not vary. France consumes seven-eighths of all our roe. Spain takes the remainder.

C.—THE HERRING FISHERY.

1. THE SPRING HERRING.

The herring (*Clupea harengus*) has from time immemorial been of great importance to the population of Scandinavia. The spring herring, so called from the season when captured, has in particular yielded the

most abundant products, and its capture has occupied to the present time the greatest number of hands.

The little we know of the spring-herring fishery in ancient times must be gathered from fragments in the works of different authors, of whom none intended to occupy himself with this particular subject. It may be inferred from these works, however, that this fishery has existed from the remotest periods as one of the principal sources of well-being for the inhabitant of the coasts, without, however, being of general interest to the rest of the population or of importance in a commercial point of view, since they were ignorant at that time of the art of salting the herring, and contented themselves with smoking or drying it in the air. After the art of salting herring became understood, this fishing assumed importance, and this is especially true since the fifteenth century. From 1567 to 1700 it was not kept up, or, at any rate, was extremely limited, but since that time it has continued to develop, except during the years from 1784 to 1808.

Since 1874 the spring herring has again disappeared from our coasts. Its previous disappearances coincided generally with a relative abundance of herring upon the southwest coast of Sweden, which, in its turn, lost the herring as soon as it reappeared in Norway. This year they have commenced to find upon the Swedish coast a herring which appears analogous to the spring herring of Norway, and one is tempted to believe, in view of this fact, that the spring herring in its migrations makes some stoppages upon the coast of Sweden. The savants do not agree about the migrations of this species of herring; some maintain that it remains all the year in the same latitude, but that it keeps more outside and comes to the coast only to spawn; others say that it undertakes long migrations to the Arctic seas. The Norwegian Government has made great efforts to throw light upon this question. Let us hope that our naturalists and naval officers, who, braving every danger, have gone two summers in succession to explore the depths of the Atlantic, will be able by the comparative study of currents and water-temperatures to contribute to a great extent in giving us more precise ideas upon the herring in general, and the spring herring in particular. That portion of the coast comprised between Capes Lindesnaes and Stat is the true home of the spring herring. To the east of Cape Lindesnaes it showed itself but exceptionally in 1760 and 1833. From 1736 to 1756 only were the fisheries at the north of Cape Stat as far as Nördmöre of importance. The most successful fishery is generally in the vicinity of Karmö, and going up the coast as far as the island of Hisken; but from 1808 to 1833 it was also good in the archipelago situated to the southwest of Bergen, with a renewal in 1864. To the south of Jaederen these fish have been caught only occasionally, especially from 1833 to 1837, toward Farsund and Flekkefjord, and in 1839 and 1840 near Egersund. Since 1860 this fishery has been carried on upon a great scale in Söndfjord (Bremanger and Kinn), and in the Nordfjord (Moldö). Söndmöre (Herö) has also

had several profitable years. In the northern fisheries, work begins ordinarily in the latter half of January, at Fröiö (parish of Bremanger); thence it is carried on toward Kinn and Batalden, and ceases generally in the beginning of February, to continue if possible in Nordfjord.

The Karmö fishery formerly began earlier than the preceding; the contrary has taken place toward the end of a more recent period. February was considered the best period.

The fishery is carried on either with nets or with seines. The net fishery is conducted by means of 20 to 25 nets to a boat, with 4 or 5 men. In the north they use 15 to 18 nets per boat. The nets are usually 10 to 12 fathoms in length. The old nets were made with meshes of $1\frac{4}{10}$ inches on the side; but the herring being counted at the time of sale, they have decreased the size of the meshes from 1.12 to 1.20 of an inch. The depth of the net was formerly calculated at 80 meshes, about eight feet deep; but since bottom-nets have come into use they are made with a depth of 12 to 15 feet.

To maintain the nets in a vertical position they at one time used floats of juniper or willow; now cork is employed exclusively. The glass floats, introduced in the cod-fishery at the Loffoden Islands, have not been tried for the herring. The nets are joined by threes and are put in the water in the evening, either near the shore or far out and near the bottom, according to the places where the fish are seen. The nets are raised in the morning, and give a result that is very variable. Sometimes one set of nets will produce as much as 20 hectolitres (50 and more bushels) of fish. A single net has been known to bring up 10 to 12 hectolitres (28 to 33 bushels). One boat has generally several combinations of nets out at the same time; but one of these sets is often more than sufficient to fill the boat.

Besides the night-fishing, one is also prosecuted in the daytime, but especially when the herring is pursued by the whale or *sey pollack;* the more virulent the pursuit, the more productive is the fishing and it is sometimes extremely profitable.

It is considered desirable for net-fishermen to be provided with reserve nets, as they are liable to lose those in use by the currents or by becoming entangled with other nets. The situation is a little ameliorated since the law has introduced more order into the fisheries. The losses are, however, still very serious, and the masses of nets are sometimes so considerable that they form floating islands, and support without sinking the weight of a great number of men. Every year are brought to the authorities hundreds of stray nets that are sold later at public sale for the benefit of the state. The product of the net-fishery is always sold in the south of Bergen to the collecting-boats which come to the spot to serve as middlemen between the fisherman and the salter.

Seine-fishing is carried on in quite a different manner. A complete equipment is composed of three seines, a large one of 100 to 150 fath-

oms long and 15 to 20 fathoms deep; a medium seine, 75 to 100 feet long by 15 deep; and a small seine (*orkastenot*), 35 to 40 fathoms long by 7½ to 10 deep. To each of these seines there belongs, in addition, a boat (that for the large seine should have a capacity of 420 to 560 bushels), several baskets of lesser dimensions, and a quantity of rigging, tarpaulins, kegs, anchors, hand-nets, painted boards, boat-hooks, fishing-glasses (water-telescopes), compasses, &c. Finally, for each series of seines a dormitory-boat is provided for the crew of 25 to 30 men, of which the chief is called "*notebas*." The cost of the equipment of such a set of seines amounts to $1,700 or $2,300.

By means of these nets the herring is taken in the following manner: When the herring is observed to reach the coast, or to penetrate into a cove or strait (sometimes it is driven there by the whale or pollack, but more often goes of its own accord), seines are extended around the mass of herring that they intend to capture; during the day the fish are generally followed by a crowd of sea-birds, but in the night they are usually alone. The entrance of the fish is ascertained by the aid of a sounding-lead suspended by a cord, which, being more or less impeded by the resistance of the school, permits an experienced hand to ascertain whether the fish is coming in. As a rule, the result of the catch depends upon the ability of the skipper, not only in recognizing the presence of the fish and in knowing how to gather them in the circle of seines, but in taking them in and detaching them from the nets—operations where the presence of mind and the quick perception of the skipper are constantly put to the proof. He cannot always choose the place to throw his seines, as this depends much on localities and various other circumstances. Frequently it is necessary to make a long sweep with ropes; they then attach boats to the two ends of the seine and frighten the fish, forcing it to remain within by means of boards painted white which are continually raised and lowered in a manner to make them see the reflection of themselves until the two ends of the seine are brought to the shore. After the herring is caught sight of, the result still depends very much on the nature of the bottom, on the force and direction of the currents, which very often disturb the nets, and on storms, which not unfrequently destroy the nets and their contents; it is under such circumstances that the commander has the most occasion to show his talent.

The product of seine-fishing is still less certain than that of the gill-net. Every year seines are heard of which have taken nothing at all, but in return there are some which make magnificent captures. It is not rare to see a single seine take 3,000 to 5,000 bushels, on some occasions 50,000 to 75,000 bushels of herring.

The seine is especially made use of south of Bergen; more northward the weather is usually much rougher, and coves favorable to this kind of fishing are rarer. Seine-fishermen have, however, been known to attain great results, permitting them to cover the deficit left by net-fishing. In Nordfjord, above all, this fishery is prosecuted with success.

The fishermen are classified according to the apparatus they employ. They live and work under very different conditions.

As to net-fishing, the boat, with all its equipment, belongs generally to a crew composed of four or five men. The boats rarely carry hired fishermen; when they do, however, these receive as their share half of the fish caught, or rather they get half their pay in catch and half in wages, the latter amounting to 6 or 7 francs a week. It is the same when a city merchant fits out a vessel, except that the compensation of the commander is higher. In every case the fishermen have with them a dormitory-boat, where as many of the crew as the boat can contain are assembled, not to separate during the continuance of the work. On board of this dormitory-boat are kept their provisions, beds, and changes of clothing.

In general, every man performs in turn the cooking for all the rest. Fifty years ago the fishermen had no dormitory-boats, but had to seek shelter anywhere in the neighborhood of the fisheries. Few found shelter, and the greater part, chilled to the bone, took refuge in boats turned over for the purpose, or passed the night exposed to the rain and tempests on some desert rock. Those considered themselves favored who could sleep under a roof, erect, supported one against the shoulders of the other. At present, even when all this hardship is considerably lightened, the lot of the fishermen is very little to be envied. Whatever the weather, it is necessary morning and evening to go to sea and cast or draw in the nets that the current has often carried away, or which have been disturbed and carried to the bottom by the interference of other fishermen. It is not rare for fishermen to return empty-handed after a profitless work and after having lost all their implements. If, on the contrary, the herring-fishery is successful and the nets are full, the fishermen must return by the aid of the oar to the nearest port where the collecting-boats are anchored, make their discount, and return to the dormitory-boat. It is necessary in the evening to set the nets again; then the fisherman has finished his fatiguing day of work, to continue day after day so long as the fishing lasts, and as soon as the weather permits him to go to sea. The herring caught are, as we have said, delivered to the collecting-boats, which transport them to the salters, but sometimes the fishermen themselves transport them thither. During this transfer, especially if it lasts long, the herring, being heaped up, is in danger of becoming spoiled, but the principal causes of loss occur in the manipulation at the salting-establishments.

As soon as the herring arrive at the salting-establishment, they are given to the dressers and salters. These in the cities are generally women; in the salting-establishments by the shore fisheries, they are more frequently girls who come from the neighboring country, and often, further, to participate in the general activity. They are usually arranged in threes, two to clean the fish and one to salt. The cleaning consists in burying a pointed knife in the throat of the fish, which allows

the drawing out of the gullet and bleeds at the same time the fish. After this operation, the herring is placed in layers in the barrel; two or three layers above the top. A barrel thus filled contains about 480 herrings. After having remained so several days, the herring being by that time saturated with salt, the barrel is filled anew and closed by special workmen (*dixelmænd*), and stored away to be examined anew, and filled again at the moment of exportation. For each bushel of herring is used one-fourth of a bushel of salt from Setubal, Cagliari, or Trapani.

The spring-herring fishery formerly occupied a large number of hands, and produced in February or March an extraordinary movement all along the length of the coast comprised between the city of Stavanger and Cape Stat. Thousands of vessels and sail of all kind continually furrowed the fjords. In every cove innumerable quantities of herring were seen hemmed in by seines (*notebrug*), and in process of being loaded on collecting-boats, which were to conduct them to the salting-establishments. Clouds of sea-birds hovering around, plunged here and there, and mounted in the air, a herring in their beaks, while numberless whales, not far from the coast, chased before them schools of herring. With the herring all this life, all this movement has disappeared. Let us hope that a near reappearance of this fish will soon revive it.

The product of the spring-herring fishery has in some years attained to a magnitude of from 600,000 to 700,000 barrels per year, and about 6,000 boats have been occupied in it. Sweden, Russia, and the German ports of the Baltic Sea are the principal countries consuming it.

It is, as stated, along the coast between Stavanger and Cape Stat that the spring-herring fishery had its seat, principally at the islands of Utsire and Karmö, at Skudesnæs, at the islands of Fæö, Rövær Espevær, at Bömmelfjord, and at Kvalvog, all situated to the south of Bergen. To the north it was at Bremanger, Fröiö, Batalden, Kinn, Tanso, and Bueland.

2. The great herring in Nordland.

The great herring is a peculiar species which from 1851 to 1875 visited the coasts of Nordland and Southern Finmark, but has again disappeared. Old documents relative to Nordland sometimes speak of a large kind of herring used in the kitchen, but only in the last twenty years has public attention been turned to this excellent species, and since then arrangements have been made for taking it on a large scale. Up to 1865 and 1866 the product of this fishery was without importance, but since then and until 1875, several hundreds of thousands of barrels have come to increase the prosperity of Nordland. Since then, as before remarked, the large herring has followed the example of the spring herring, and departed without any one knowing whither. Will it ever return? It is impossible to say.

The pursuit of this species, which used to begin in the beginning of the month of September, was prosecuted with bar-nets or seines, so as to inclose all the herring entering into such a cove or inlet. The great herring contained roe and milt like that of the spring herring.

As sold by the intervention of city dealers it was first examined and stamped by the sworn inspector; the brine was then taken away and the barrel filled up again, several handfuls of salt being added, and the merchandise was then ready for export. The spring herring was similarly treated.

A barrel of spring herring contained thus 500 to 550 fish, 12 to $12\frac{3}{4}$ inches in length. A barrel of great herring contained about 450 herrings, 14 inches in length; its net weight was 240 to 255 pounds. The countries consuming them are the same as those receiving the spring herring; that is, Sweden, Russia, and the German ports of the Baltic and North Sea. The districts where the great herring was especially found were Langnæs, Fleinvær, Fuglevær, Aasvær, Skibotvær, all situated in Nordland.

3. The summer herring.

The summer herring, which was formerly still more uncertain in its appearance than the spring herring, has in late years become a regular visitant to our coasts, and the product has attained dimensions quite as considerable as those of the spring herring in the best years.

The fisheries are extended over a very long line, from the heights of Bergen to Southern Finmark. The pursuit commences in July and continues to December.

The size and the quality of the fish improve toward autumn and diminish again toward winter. The implements of capture employed are similar to those used for the spring herring, with some modifications imposed by the differences of weather and place. The supply of fishermen for this work is not nearly as considerable as it was for the spring herring; most frequently the fishermen of the locality prosecute it. It is true they cannot pass their nights at home, but they are so few in number that the neighboring farms can accommodate them. The dormitory-boats thus become superfluous, especially as the fishing takes place principally during the fine season.

The summer herring are caught with the seine or net. To the south the seine is used exclusively; in the Romsdal, but, above all, in the environs of Drontheim, and more to the north, the net is employed. In the Gulf of Namsos and other places they use floating or drift nets, with which, when the nights become dark, they catch quite considerable quantities at the mouth of the Gulf of Namsos and in the Gulf of Folden. The reason that toward the south they employ gill-nets less frequently is probably that the intestines of the herring are so filled with undigested food (*aat*) that they cannot be salted before removing this substance, without which the fish would soon burst. It is with this object in view that the herring are left for three consecutive days in the

seine, the contents of the stomach becoming digested in that time; after this they are ready for salting.

Whether performed with the net or seine, nearly the same process is used as for the spring herring; but, owing to the inferior dimensions of the fish, smaller meshes are required.

The summer herring, as to size, is always more varied than the spring herring; it is necessary, too, each time that the seine is raised, to proceed to a minute assortment into four categories: large merchantable herring; small or medium merchantable herring; large Christiania herring; small Christiania herring. The two first kinds are the largest and fattest, with a little head and very large gall; they are used principally for exportation. The latter two varieties, on the contrary, smaller and not so good, are used principally in interior consumption, above all, in the diocese of Christiania; in latter years, however, they have been exported in comparatively great quantities to the Baltic ports.

When our summer herring is fat and large, that is to say, of the first quality, which, by the by, does not take place every year, it is quite an exceptional article of merchandise, which, when well prepared, far surpasses the most desirable foreign sorts, even the Flemish herring, since this latter which contains a good deal of spawn and milt has used up all its substance in their production, while our summer herring has neither spawn nor milt, but is full of fat.

The summer herring as soon as caught is divided into four classes, that is, as already stated, into merchantable herring, K K, of about 10 inches in length; great herring (merchantable), medium herring or small merchantable herring, K, of 9.40 inches; large Christiania herring, M, of 8 inches; and small Christiania herring, C, of 7.20 inches.

The salting is done on shore; the barrels being headed, they put them on board one after the other, when they are shipped to the great ports of exportation. The fatter and more tender the fish, the less closely are the barrels packed. The qualities K K and K are generally worth five or six francs more, and the quality C, five to seven and a half francs less, than the quality M. The greater part of the summer herring is shipped on account of the Norwegian dealers in the Baltic ports, Denmark, Sweden, Hamburg, and Russia. That shipped for foreign ports receives at first the official stamp of a sworn controller (*sildevrager*). Austria takes a certain quantity of M and C, from which the head and entrails are removed.

A barrel of summer herring prepared for exportation contains the following number of fish: of K K, 800 herrings; of K, 1,000 herrings; of M, 1,200 to 1,400 herrings; of C, 1,800 to 2,000 herrings. The net weight of the barrel is rarely more than 220 pounds.

D.—THE BRISLING FISHERY.

The brisling or sprat (*Clupea sprattus*) is not a mere variety of the ordinary herring, but is a distinct species. Though smaller than the

ordinary herring, it much resembles it, and often accompanies it, especially in the summer. The sprat is easily distinguished, however, by its belly, which is sharp or serrated. Like the ordinary summer herring, it seeks the coast in nearly all our fjords, from the frontier of Sweden to Romsdal, from spring to the end of autumn, and it comes usually in large schools. It is most abundant in the deep fjords of the prefectures of Stavanger and South Bergenhus. The spring brisling is distinguished from that of the autumn; the former is poor and not of great value, while the latter is a fine, fat, and good fish, so that many persons prefer it to the summer herring itself. It is taken almost exclusively with very small meshed seines. These seines are very expensive, but need not be so long as those required for the herring fishery. Generally in commencing to fish an ordinary summer-herring seine is placed in the water. This startles the brisling and serves to drive it in, but before the fish is completely inclosed a seine with fine meshes is cast outside of the large one, when the first seine is withdrawn.

In the autumn, when the brisling is pursued by the tunny, of which it is the favorite food, it comes near our coast, and is then easy of capture. With a seine of moderate dimensions several hundred barrels may often be taken. Like the summer herring, it is well to leave it three days in the seine to give it time to digest the mass of food it has swallowed.

The brisling is frequently prepared into anchovies; that is, it is pickled with different kinds of spices. The summer herring cannot be prepared in this way, but it is as applicable to the spring as to the autumn brisling; the latter, however, gives a much better product. The operation is performed in kegs of different sizes, but containing rarely more than 8 or 10 quarts. The anchovy is consumed in this country, but it is also exported to a great extent to Denmark, Hamburg, and England.

E.—THE MACKEREL FISHERY.

The mackerel is found in great quantity upon the whole coast from the Swedish frontier to the eminence of Söndmöre. It is distinguished, according to the period when sought after, into summer and fall mackerel. The summer catch is alone of importance, although furnishing a poorer article. The autumn catch is rarely productive, and then in but few localities, so that few fishermen are occupied by it. The summer fishing commences toward the 20th of May, provided the weather be not too cold.

1. Apparatus and methods in use.

It is not long since this fishery was prosecuted with trailing or trolling lines, but recently drift-nets have come into use. As it is very lucrative, above all since the English have been in the habit of buying the mackerel for shipment to England in ice, all the maritime popula-

tion of the south and west has thrown itself with avidity upon its development, especially as it takes place at a period when the land requires few hands for working. The mackerel is taken by the following methods:

a. Drailing or trolling.—A fast sail-boat, of greater or less size, manned by four to six men, proceeds out to sea, sometimes to the distance of ten or twelve miles from the shore, in a good breeze and under an overcast sky. A long line is used with an oval lead at the end, weighing a couple of pounds, and provided with two hooks fixed at different heights. When the school of mackerel shows itself (it usually keeps at the surface), 6 or 8 lines, or even more, are placed in the water, which drag behind the boat, this going with full sails. The lines are baited with pieces of red cloth or with portions of the lips of the mackerel. The mackerel being very voracious, bites excellently, and the product is often considerable. A boat thus equipped can in one day capture 2,500 to 3,500 mackerel.

b. Fishing with drift gill-nets.—This is the most reasonable and advantageous method, but it requires some capital. The method of procedure is the same as for the herring, but it is necessary to proceed far from the shore, and the size of the meshes must be suitably modified. A mackerel net is 36 fathoms long and 80 meshes deep, with meshes of 1.60 inches; it is made of very fine thread (hemp, flax, or cotton). A complete set consists of 25 to 50, generally, however, 40 nets, forming about 1,300 or 1,400 fathoms by a depth of 10½ feet. This line of nets is maintained in a vertical position by a series of cork-floats on top and a lot of little stones at the bottom, and by the assistance of a boat the line is kept stretched out. The mackerel is easily taken, especially at night and under a cloudy sky. The average catch per boat is from 600 to 700 a night, perhaps 20,000 in a whole season; but there are cases when one boat can take by itself double this quantity. The boats vary in size; at the north of Cape Lindesnaes they are the same as are used for the spring herring and have a crew of three or four men; to the east of the cape the boats are larger, but have only two or three men, and only half as many nets, these being much more likely to be entangled and mixed by the numerous sail which frequent the coasts of the Skager Rack.

It may be safely said that 3,000 boats are employed in this fishery. The vessels leave the coast in the evening, visit the nets during the night, and return in the morning. The best season is from the end of May to the end of June. It may be easily imagined that the product is very considerable, for, from each port and cove in the two dioceses of Christiania and Christiansund mackerel fishermen set out, and they are stimulated still more by the high prices due to the English.

Drift-net fishing is prosecuted especially in the vicinity of Cape Lindesnaes; many boats manned in each of the ports of the country pursue the mackerel without losing a night until the middle of July.

c. Fixed nets, seines, and bar-nets.—The mackerel is caught, too, with fixed nets (*saettegarn*), seines (*rykkenot*), and bar-nets (*kastenot*). The fixed nets are cast either just under the water or at the bottom, but this method is not very productive, the nights being too clear. It is more successful when the mackerel is pursuing schools of newly-hatched herrings, because then they approach the coast. The seines and bar-seines give place sometimes to a productive fishing when the fall mackerels enter the fjords; 20,000 have been taken in one night.

2. Preparation of the mackerel and the trade.

Formerly the mackerel was salted and exported in barrels. Its principal market was Eastern Norway, Sweden, and a small portion of England. The roe furnished besides 4,000 to 5,000 barrels a year. More recently they have begun to send to England in suitable vessels almost all the production, which for this purpose is preserved in ice.

F.—THE LOBSTER FISHERY.

The lobster is the largest and most useful of the European crustaceans. It is found on all the coast of Norway, and as far north as the Arctic Circle, in the sea and in the fiords, but above all between Christiansand and Söndmöre.

In winter the lobster remains in deep waters; it returns to the coast in the spring and resorts to rocky bottoms, covered with sea-weed. It has always been the object of an active pursuit, but it would have remained without importance if the exportation and certain sale in England of the living lobster had not stimulated the ardor of our fishermen. It employs a considerable number of hands, and has become very general and lucrative, so much the more as it is accessible to the poorest and most infirm, requiring very simple and cheap implements, and to manage all merely the experience necessary to handle an oar.

The most primitive tool consists of a pair of wooden tongs 3 to 4 yards long, with which the lobster is sought for (preferably in the morning), in quiet, clear weather, the lobster at such times loving to resort to the sea-weed, nourishing itself with the little animals that infest it. This method of capture is only practicable when it comes sufficiently near the shore, and when the weather is tranquil; sometimes, too, the lobster is pinched so strongly that it dies.

Hardly anything is used now for taking the lobster but *tines* or barrels. These are made of slender rods nailed at considerable intervals on small hoops. The intervals are filled with cords of hemp stretched across so as to form a sort of net. At each end is a funnel with a large enough mouth to permit the entrance of the lobster. On top of the barrel is a cover closing by a bolt, and in the middle is hung another bolt or peg to which the bait is attached. Under it is attached a flat stone to make it descend, and to one of the upper bars is a cord permitting the barrel to descend to the bottom at a depth of two to four fathoms.

The lobster, which creeps on the bottom, sees or smells the bait, and seeking to get it goes round the barrel until he finds the funnel; he enters it and finds himself caught. Sometimes in drawing up the barrel a lobster is found lying upon it. The fishermen tend these pots ordinarily in pairs. They use all sorts of fishes for bait, but employ neither mackerel nor herring, experience having shown that the lobster taken with such bait does not live long.

The barrels (or pots) are placed in the water in the morning and evening, and the fishermen can, in the interval, procure proper bait, as cod, pollack, &c. As soon as the lobster is taken from the *tine* his claws are bound with pack-thread; otherwise they would destroy each other. The fisherman then unbinds his prey and places it in a special box, which he keeps submerged at the bottom of the sea, until he can carry to the collecting-boat the product of his catch; left in the water near the surface it would soon die. Each pair of fishermen has ordinarily as many pots as the boat can contain, perhaps 30 to 50, and this is enough to give them plenty to do, the day hardly being long enough to provide the necessary bait. As long as the fishing lasts they wander in their boats from one shore, or fjord, to another, regulating their movements by the chance of meeting the lobster.

Anybody is allowed to take lobsters, except from July 15 to October 15, which constitutes a close time, during which this fishery is prohibited. Nearly all the lobsters are disposed of to the English, who have made contracts with the fishermen, and come to seek the product in small vessels built specially for the purpose.

To the same class as the lobster belongs the crab (*pagure*), which inhabits nearly the same places, and is found in incredible quantity in some of the fiords of our west coast, especially where it is rocky and perpendicular. They are taken, like lobsters, in *tines* (except that these are larger and the bars are closer together); the tines are baited in the same manner as for the lobster. The crabs, which are often 10 or 12 inches long, are so abundant that 40 or 50 are sometimes taken in a single tine. Unfortunately, the profit on this fishery is very moderate, the crab not being eaten by the maritime population, and its price being very low in the markets of Bergen and Stavanger. Cut up fine it is used as bait for catching the little *sey* or pollack, and sometimes the autumn mackerel.

Lately they have commenced to preserve the crab in hermetically-sealed boxes; specimens of this new product figure at the Paris Exposition, and there is ground for the hope that, thanks to this preparation, the crab will in time find a foreign market.

The prawn is caught also in great abundance, especially in the east. The Svelvig prawn (*Pandolus borealis*), which is distinguished by its red color and is two or three times as large as the ordinary prawn, is caught exclusively at Svelvig, and sold at Drammen, where it is much sought after.

G.—THE WHALE FISHERY.

Eight or nine years ago a bold speculator, Mr. Svend Foyn, of Tönsberg, commenced to capture the whale on the coasts of Finmark by means of a special steamer. The whales are chased with harpoons thrown by cannon expressly constructed for the purpose. This harpoon is charged at the lower part with an explosive ball which bursts as soon as the harpoon has penetrated into the flesh of the animal, and kills it instantly. The result is very lucrative, Mr. Foyn having captured in certain years as much as forty and odd whales.*

Admitting that a Finmark whale furnishes about 2,100 gallons of raw oil, worth 32 cents a gallon, and $40 to $60 worth of whalebones, it represents thus a value of $600 or $700.

A company for catching the whale has been established, and another is in process of formation.†

H.—THE SEAL FISHERY.

The seals which are the object of this fishery are the Greenland seal (*Phoca grœnlandica*) and the hooded or bonnet seal (*Cystophora cristata*). The Norwegian sailors pursue them in the icy sea between Greenland, Spitzbergen, and the island of Jan-Mayen. Formerly, they occurred even upon the coast of Finmark.

The ship-owners engaged in the seal fishery belong principally to the city of Tönsberg. Steamers are now almost exclusively employed. The expeditions set out in March, April, and May, and the annual product has reached about $300,000. The cost of the seal-fishery equipment is comparatively expensive; the crew averages 46 men to a vessel, and their pay is very high; the product is therefore rarely very lucrative. The vessels, sheathed with wood and iron, carry eight or nine canoes that are lowered into the sea when the pursuit is about to begin. The seal is killed with the gun, and after being taken on board is flayed and the fat gathered in the raw condition in large casks.

The city of Tromsö, from April to September, mans several boats to go to the island of Jan-Mayen to hunt adult seals. As to the spring fishery, the seals are attacked when they have just brought forth their young, which causes the loss of a great number of the latter and frightens the females, who take refuge in places inaccessible to vessels. This fishery has been prosecuted in an equally barbarous manner by the sailors of all nations, assuming, indeed, the character of a war of extermination, until Norway took the initiative in international measures for the protection of the animals. Norwegians are prohibited to go in pursuit of the seal before the 3d of April, the period when the young can look out for themselves, in the area extending between 67° and 75° north latitude, and 5° east and 17° west of the meridian of Greenwich.

The capture of the gulf or harbor seal (*Phoca vitulina*), dolphin or por-

* Nearly ninety in 1877.—TRANSLATOR.

† The whales taken are for the most part finbacks.—TRANSLATOR.

poise (*hvidfisk*), and the walrus, gives rise to several different industries, but their importance is secondary.

I.—THE SALMON FISHERY.

The salmon and trout are also sea-fishes, but they are principally caught at the entrance of rivers at the time when they endeavor to ascend to spawn. The salmon fishery has a certain importance; it commences in April, and lasts until September. The salmon is taken for the most part by nets, and is very much sought after on account of its succulent flesh. It is exported almost exclusively to England, fresh, preserved in ice. The salmon smoked is equally esteemed; it is consumed for the most part in Norway, but a certain quantity is exported to Denmark and Germany.

The salmon seemed to be on the decrease several years ago; but in the last two or three years, since fishing during the spawning period has been prohibited, it has apparently increased in numbers. The price has gone up considerably; ten years ago a pound of fresh salmon was rarely worth more than 6 or 7 cents, while now it brings from 12 to 14.

J.—MISCELLANEOUS FISHERIES.

Oysters are found, too, on the coast of Norway. Although attempts in oyster-culture have been made in the neighborhood of Stavanger, the oyster becomes rarer and rarer, and its importance as an object of export is continually decreasing.

The fresh-water fisheries, of which the importance in a general point of view is very secondary, and of which the product is estimated at $240,000 a year, comprise the different genera of Coregonus, pike, perch, bream, eel-pout, &c.

In addition to the principal and secondary fisheries may be noted here different species which occur more or less frequently, and are caught for their flesh or liver. These are, first, the *Hippoglossus*, halibut (*Kveite*); then, in the great family of the sharks, the *Selache maxima*, barking or bone shark (*Brygde*), the *Squalus acanthias*, dog-fish (*Pighai*), and the *Scymnus borealis*, *Somniosus microcephalus*,* or nurse-shark (*Haakjaerring*).

The census of 1865 gives as employed in the fisheries 78,703 individuals—about 4.6 per cent. of the entire population of Norway.

---

* Mr. Hermann Baars in, the Fischerei-industrie Norwegens, Christiania, 1873, goes into rather more detail than Mr. Friele, in regard to the capture of sharks for their livers. The species which he calls *Scymnus borealis* is better known on our own coast as the Ground, Sleeper, or Gurry shark, *Somniosus microcephalus*, Bloch, and is found in great abundance along the coast of Western Norway, and especially along certain banks of the Polar Sea. These banks lie at a distance of 15 to 20 miles from the land, at a depth of 250 to 300 fathoms. Decked boats are used in their capture, although they seldom exceed fifteen tons burden, with a crew of five or six men.

The mode of capture is by means of a line, about four-tenths of an inch in diameter,

K.—VALUE OF THE PRINCIPAL PRODUCTS OF THE NORWAY FISHERIES.

1. VALUE AT PLACES OF EXPORT.

1876.

19,683,700 kilos. (43,394,685 pounds) dried fish, at $9 per 100 kilos.*		$1,771,533
33,038,050 kilos. (72,835,685 pounds) *klipfisch*, at $11 per 100 kilos		3,634,200
91,428 barrels salted cod, at $5.80 per barrel		530,282
12,176 barrels large herring	at $5.60 per barrel.	5,023,805
23,607 barrels spring herring		
861,325 barrels summer herring, brisling, &c.		

to which a lead of six to nine pounds is attached as a sinker. This line ends in a tinned or galvanized-iron chain, of about three fathoms in length, so that it cannot be injured by the familiar habit of the fish, hereafter to be described.

The hooks are made of strong iron or steel, nearly four-tenths of an inch in diameter. As soon as the boats reach the bank, they are brought to anchor, and the cord let down; before this, however, a perforated box, filled with rancid or putrid seal blubber, is fastened about two fathoms above the hook. This substance escapes through the holes of the box, and is carried along by the water, thus attracting the fish to the hook, which is also baited with seal blubber.

The fisherman holds the line in the hand, as in cod-fishing, and as soon as it is observed that the animal has taken the hook, by a sudden jerk this is forced into the mouth. As soon as captured, the shark rolls himself round and round in the chain, which is not injured by the rough, file-like skin, as would be the case with a line. The animal is then hauled up, sometimes by the use of a windlass. As soon as it appears above the surface, it is killed and held fast until the belly is opened, and the liver removed. The swimming bladder is then filled with air by means of a pipe, so that the carcass will not sink. It is then fastened to the stern of the vessel. Sometimes other sharks follow the carcass of the dead one, and are occasionally caught by means of gaffs.

When the boats leave the banks, a buoy is generally fastened to each carcass, so that it may remain at the surface without sinking. Otherwise it would be eaten by its fellows, who would neglect the baited hooks.

The yield of this fishery is not only dependent upon the wind and weather, which are so inconstant in the Arctic seas, but also upon the variation in the size of the fish and their abundance. Some of the fish furnish a liver weighing only 25 to 30 pounds, while from others livers of 220 to 450 pounds are obtained.

Of late years the carcasses of these sharks have been brought ashore, for the purpose of being manufactured into manure or guano; especially when they are taken inshore near the land, as is the case sometimes in the winter on the coast of Finmark, where they are sometimes taken with trawl lines. These trawls usually carry thirty hooks, six or seven fathoms apart, and are kept immediately above the bottom by means of glass floats.

The annual yield from this fishery amounts to eight to ten thousand barrels of livers, worth one hundred and fifty thousand gulden.

The oil of this animal, obtained by steam heating, is extremely fine, and is used for purposes of illumination. The undissolved portions of the liver are then boiled, and furnish the brown tanner's oil.—TRANSLATOR.

* The equivalent of the kilo. (kilogram) is 2.2046 pounds. The values originally given in francs have been reduced to dollars of five francs each.—TRANSLATOR.

45,203 barrels cod roe, at $12	$542,436
95,345 barrels cod-liver oil, at $16	1,525,520
4,989,450 kilos. (10,999,741 pounds) fish guano 1,754,800 kilos. (4,068,632 pounds) fresh fish 1,270,348 pieces of lobster	400,000
Total	13,427,776

1877.

21,080,000 kilos. (46,472,968 pounds) dried fish, at $9.20 per 100 kilos	$1,939,360
45,870,000 kilos. (101,135,002 pounds) *klipfisch*, at $8.20 per 100 kilos	3,761,340
5,100 barrels of large herring 16,600 barrels spring herring 661,200 barrels summer herring, brisling, &c. — at $4.70 per barrel.	3,209,630
53,700 barrels cod-roe, at $6.60	408,120
130,600 barrels liver oil, at $14.80	1,932,880
80,000 barrels salted cod, at $5.40	432,000
Fish and lobster guano, valued at	360,000
Total	12,043,330

(The official detailed lists of 1877 are not yet published.)

Adding for the production of the small daily fisheries and the consumption in the country itself of about $5,000,000 a year, the total value of the Norwegian fisheries amounts to, for 1876, $17,427,776, and for 1877, $16,043,330—a large amount for a country having hardly two millions of inhabitants.

2. VALUE AT THE FISHERIES.*

Winter and spring fisheries:	
Cod	$3,022,000
Summer fisheries:	
Pollack, ling, molve, &c	560,000
Herring (including brisling or sprats)	2,188,000
Mackerel	174,000
Salmon	128,000
Lobster	100,000
Total	6,172,000

3. STATISTICS OF THE WINTER AND SPRING FISHERIES.

a. Fishermen.

Total number	$62,757
Those using nets exclusively	19,790
Those using lines exclusively	16,525
Those using bottom lines or palancres (trawls)	6,804

* Five francs considered as a dollar.

Those using hand-lines and both lines and nets	$2,830
Those using trawl-lines and net-trawls	7,388
Those using hand-lines and trawls	9,300
Those using nets, lines, and trawls	110

b. Boats.

Total number	15,135
Provided with nets alone	3,501
Provided with lines only	5,052
Bottom lines or palancres (trawls)	2,033
Lines and nets	557
Trawls and nets	1,253
Lines and trawls	2,719
Nets, lines, and trawls	20

c. Quantities of fish.

Total catch	fish	40,101,400
Caught with the net	fish	20,723,200
Caught with the line	fish	16,060,300
Caught with palancres or trawls	fish	3,317,900
Quantity of liver taken	barrels	93,482
Quantity of roe taken	barrels	38,025
Heads sold	pieces	10,679,000

d. Value on the spot of the catch.

Total value	$3,022,018
Fish without liver or roe	2,142,988
Liver	516,408
Roe	345,563
Heads sold	13,470
Cold sold whole	3,588

4. Statistics of the summer fishery.

a. The herring fishery.

Total number of fishermen	48,831	Total product of catch	bbls	617,859
Fishing with nets	25,015	Caught with the net	bbls	216,612
Fishing with seines	23,816	Caught with seine	bbls	401,247
Boats furnished with nets	12,463	Total value		$2,094,709
Companies provided with seines	1,862			

b. The mackerel fishery.

Total number fishermen	3,436	Quantity caught	fish	4,191,561
Fishing with the net	3,113	Caught with the net	fish	4,034,661
Number of boats	1,047	Total value		$174,000
Boats furnished with nets	943			

5. Products of other fisheries.

The brisling fishery	bbls	109,021
The salmon fishery	kilos	411,570
The lobster fishery	pieces	1,140,514

VIII.—REPORT OF THE SEA-FISHERIES OF THE LÄN OF GÖTEBORG AND BOHUS IN THE YEAR 1877.*

By Gerhard von Yhlen.

A.—THE GREAT FISHERY.

The Skrejd fishery.†—Thirty-seven vessels with 322 crew engaged in this fishery. According to statements from Norway the average earnings per man amounted to $157.17, equivalent to 1,386 codfish, sold at 11 cents per "round fish." This distant fishery caused considerable losses of implements and of one man's life.

The Storeggen fishery, during the summer season, was carried on by 11 vessels with 144 crew. The average earnings per man were $173.63. Scarcity of fish and rough weather caused the products to be so small.

The Jæderen fishery was carried on by 32 craft with 388 crew. The earnings, at a low estimate, average $128.17 per man. To obtain complete statistics of this fishery is, as previously remarked, more difficult than is the case with those above, the products not being sold to dealers, but generally shared ("bytt") between the fishermen, and sold by them in small lots.

One craft from Gullholmen, with 11 crew, was totally lost in this fishery during a gale in the month of August. She was insured in the Fishermen's Association.

The Jutland Reef was visited by 30 fishing smacks, with 254 crew. The average earnings per man were about $124.38.

The Kattegat fishery was carried on with 57 craft and 327 crew. The average earnings per man were about $91.80.

Besides these fisheries, several vessels resorted to various other fishing banks, and it appears that the Skrejd fishery in winter time, and fishery on the reef during the summer, secure the best fares. One has in this way arrived at a gross profit of $3,105 for 8 men.

The market places for each fishing craft are stated in the tables, and from them may be seen that every year more vessels come to Norwegian ports for a market. The Norwegian merchants, who thoroughly understand this business—which cannot be said of the Swedish merchants—have already found their advantage in furnishing loans to the outfitting of Swedish bank vessels; and the Norwegian "customers-system"‡ is not far from being introduced in Bohus-Län.

---

*Translated by Josua Lindahl, Ph. D.

†The cod-fishery off Aalesund, Norway.—(J. L.)

‡The Norwegian merchants buy the fish "round" from the Swedish fishermen, and dress it and cure it on shore.—(J. L.)

The measured craft are registered at a tonnage calculated according to Rule II.* All others have been treated as stated in my previous reports. The herring fishery and other occupations have prevented me from measuring all of them. Twenty-four new craft have this year been added to the fishing fleet. The summer fishery in larger fishing smacks on the Jutland Reef is growing more important every year. Market is generally sought in the southern ports of Norway.

The Fishermen's Association, besides having suffered from the loss of the above craft, met with heavier losses than ever before through the destruction of apparatus in the Skrejd and Storreggen fisheries. The assessment levied to meet these losses was, for the banking vessels, 8.4 per cent. of their insured value.

In consequence of this, and on account of the inequality in risk, it was resolved at a meeting of the Insurance Association, January 21, that a special section of the association be formed that will grant insurance only for total loss, and not undertake to indemnify for damages to vessels or for loss of apparatus.

This is the final aim of the association toward which it now seems to have approached one step nearer. When the association was formed, eight years ago, the loss of one gang of trawl-lines or of one anchor would have paralyzed the whole boat's crew. This is now no more the case in any degree worth mentioning.

B.—THE MACKEREL FISHERY.

The supply of fish was almost equal to that of the previous year. Price and demand also were about the same.

Mackerel was sent to Stockholm in ice, but this undertaking proved a financial failure. The railroad freight for the heavy ice-boxes, and the low price of mackerel in Stockholm, where this nutritious fish is not appreciated, interfered with the efforts to supply the capital with this sea-fish in a fresh condition in summer time. It will remain a mere object of desire, until the railroad administration will furnish American refrigerator-cars. It paid well, however, to ship ice-packed mackerel to Christiania, and this undertaking met with a cheerful approval from the Norwegians.

The preserving of mackerel in oil and its marinating are still practiced. The products of Edward Nilsson, of Grebbestad, are of superior quality, and the best of all that are made in the Län.

The "bankers" from Oroust still use mackerel-nets for catching bait.

The losses, also, in this fishery have been unusually heavy, and contributions have been leviedto the amount of 6.6 per cent. of the insured value.

The hook-and-line ("dörj") fishing is gradually being abandoned, and during the last three years has given insignificant returns for the labor.

* In English register tons, "accurate tonnage," outside measurement.

C.—THE WINTER FISHERY.

The requirement of this fishery being open water, it is obvious that as during the winter of 1877 the "Skärgård" was ice-bound for three months, the products of that year were materially reduced. The autumn, with constant supply of fresh herring-bait and unusual abundance of fish, especially cod, gave full compensation as far as quantity is regarded; but the cheap herring which filled the markets, and could be bought for next to nothing, depressed the price of the greater fish as well as of other victuals, which fell in price by 25 per cent., and thus the fishermen earned less than they had calculated. Since the erection of the fish-hall in Göteborg, the price of fish has never been as low as in the fall of 1877.

The railroad statistics are not at my disposal, but I know from reliable sources that the transportation of cod and haddock was many times larger during last fall than ever before.

Two men perished in this fishery.

Villages in the Southern "Skärgård," that some years ago adopted fishing with trawl-line in larger decked boats, are energetically increasing this business. The same method was last year adopted by the Wrångö fishermen too, who now are running three such boats.

Asperö is the only place where, on account of want of a suitable harbor, the old method of fishing in open boats must still be continued.

The Hönö fishermen have adopted the Danish flounder-seine, and are succeeding well. This implement is managed from a boat in the open sea, and can be used everywhere where flounders occur. It is a sort of trawl-net, but simpler and smaller, as well less yielding as less injurious to the fishery. It is urged by some that the trawl-net ought to be prohibited.

D.—THE HERRING AND SPRAT FISHERIES.

a. The herring fishery.—Since the last herring-period, which ended in the year 1808, this fishery has never been so productive as during the fall of 1877 and winter of 1878. A great ingress of sea-herring appeared last fall in the northern parts of the Län, and the herring remained there until in the month of March. The first ingress consisted of "*lodd-herring*," which was obtained in the district of Fjellbacka, in the beginning and middle of November. By the 17th or 18th of November the lodd-herring had expelled the sprats, or mixed with them, so that the hauls contained almost exclusively lodd-herring. Now the schools filled all fjords, and one could literally lock in as much herring as he could sell. The uncountable swarms of sea-gulls, especially the hyperborean "Rinkja," *Larus tridactylus*, indicated that these schools were something different from the schools of lodd-herring generally visiting the coast. Also, the Wäderö and Sotö Fjords had throughout the autumn presented the spectacle of large schools of herring followed by the common "herring-followers," viz, whales and sea-gulls.

By the end of November lodd-herring was discovered in the district of Strömstad; and Koster fjord also displayed "herring-signs" on a large scale, even more so than the southern fjords.

All observations indicated that this ingress into Koster Fjord had passed by the north of Wäderö.

Almost simultaneously lodd-herring was discovered also north of the Koster Islands, as far as to Hvalerö.

Everywhere the herring came from the south and went northward.

Already about November 20 "*great-herrings*" were occasionally found among the lodd-herring in the district of Fjellbacka; they were 12 inches long and upwards, full of "inmeat," that is, roe and milt, perfectly mature and ready for spawning.

November 28 a few barrels of almost exclusively such herring were caught in a small seine at the Wäderö pilot-station. On December 1 and following days so much of this great-herring was obtained among the lodd-herring in the inner bays of Fjellbacka that people began salting for household use, and fishermen from the district of Kungshamn, who had come all the way up here to fish outside the island, got exclusively great-herrings in their seines. Such was the case with one man from Smögen, who, December 1, fished at Wedholmen, and with the Fjellbacka fishermen at Trinisla and Florö on December 3, 4, and 5.

On December 12 great-herring was found at North Dyngö, where 25 barrels were caught in one haul, and shortly afterward great-herring was found in every fjord in the "Skärgård" of Fjellbacka, all the way up to Grebbestad. The main body of these schools consisted of the same big "inmeat-herring" as that caught at Wäderö. Many of these herrings had the roe and milt running. But also herring which had already spawned were met with, and immature herring with some fat still left; and as a rule the herring was very much mixed.

The same kind of herring was caught in Bottna Fjord December 10, and on the 16th it occurred in great packs as well in this fjord as in other branches of Sote Fjord. It was remarked—and this coincides with my own observations—that these southern schools mainly consisted of bigger individuals, and that more empty herring was here found in the hauls than farther to the north in the fishery.

On the 26th and 27th a large school entered into the so-called Hollander's Bay, at Smögen, where 1,200 barrels were inclosed in one lork; nearly all of it was empty herring.

In the fishery of Strömstad no great-herring was seen until December 20, but then within a couple of days they had entered, also here, into every fjord all the way up in Säcke Fjord, and in the waters bordering on Norway. This herring had spawn, though very little developed.

About New Year's day the great-herring was standing outside, and lodd-herring inside in most every fjord, from Smögen to Vagnarberg—an extent of more than 10 mil*—accompanied by the usual herring fol-

* 1 mil = 6.64 statute miles.

lowers, viz, whale of larger or smaller species, and innumerable swarms of sea-birds. It was remarked that the Gannet or "Sillbas," *Sula bassana*, properly belonging to the Scotch fisheries, but exceedingly common here during previous great-herring fisheries, did not this time appear here. Every one of the birds that followed the herring belonged to some Scandinavian species or variety.

Up to January 9 the herring schools had not changed positions, but after that day the great-herring had left the inner fjords and could nowhere be caught in the nets within the district of Strömstad. Only north of Hafsten Sound a smaller school remained.

The herring not only went for deeper water, but they altogether abandoned the locality. Thus it was noticed that the herring, like a current, rushed out through the shallow Koster Sound, and the "herring-indicators"—whales and birds—showed that the schools were drawing out in the deep Koster Fjord, and under the group of islands off the fjord. The same was the fact in the Wäderö Fjord, though the herring still was standing at the outer islets, and in the sounds of Florö, Hästvom, and Dyngö.

In the second week of January the herring occupied about the same position as in the middle of December, one month earlier. The fishery was thus limited to only a few localities, almost before it had regularly commenced, and when purchasers arrived, and the salting began, the herring was just drawing out. The supply, however, was so large at places where herring still remained, that it was quite sufficient for all. But the largest and best herring was gone, and all what now was obtained was a poor, immature, and lean herring.

On the 14th of January the herring was found only among the outer skerries, extending about 1½ mil within the district of Fjellbacka, besides a small ingress, which, on the 10th, had been noticed at Hällö, north of Malmö. Nothing but lodd-herring remained in the fjords. Forty-two seines were in use in the fishery in the district of Fjellbacka. Herring was salted in 26 steamers and 10 sailing-vessels, used as hulks, while smaller craft and boats were engaged in the transportation of herring to railway stations and salteries.

On January 22, great-herring was again noticed at Styrsö and Saltö, district of Strömstad, and the herring remained fourteen days among the skerries that extend from the said islands down to Hafsten Sound.

On the 25th, herring also was discovered at the inner islets near Fjellbacka. A lock was closed around 2,100 barrels of great-herring at Valö, the market price of the day making this quantity equivalent to \$2,197.80. Also, some smaller throws with seines were made in the same "steg," which is supposed to have been the "tail" of the larger schools which had been standing farther south and now were drawing seaward through the inner northern sounds. Of this "tail" some herring was caught off Grebbestad as late as February 20. The fishery continued undiminished in the outer skerries, and the district of Fjellbacka until

the end of January, but for every week it drew farther northward and nearer to the open sea. After the beginning of the month of February the herring fishery decreased everywhere, and may be said to have ended with the 15th of said month. There were, however, still later made some hauls of very much mixed great-herring off Grebbestad, at Morö and Eggerö, and in the neighborhood of Lysekil, but after March 1 no more such herring was obtained.

The lodd-herring still remained in the fjords, and, just north of Fjellbacka, a lock was closed in March, which required three weeks to be emptied. The receipts on sales amounted to more than $2,160, and the contents of the lock were estimated at not less than 10,000 barrels. Lodd-herring was fished to supply the large demand in the interior provinces until the middle of March, when also this herring disappeared.

It deserves to be mentioned that by the middle of February great quantities of herring-fry appeared in the outer skerries in the district of Fjellbacka. These fry were about two inches long, and were evidently hatched from roe spawned during the previous fall.

The herring obtained represented various stages of age and development, viz:

1. *Lodd-herring*, bigger than those usually found here. The name was applied to herring about one year old, or less than two years.

2. *Nearly fullgrown, but immature, herring*, with no generative organs yet developed. This herring has been called "*Matties-herring*," translated "Virgin herring." It is also called "*fat-herring*," although exceedingly lean. The Scotch fishermen who took part in the fishery said that among them such herring was called "immature herring," not "matties." These names and classifications not having the same signification in different countries, because the herring vary in form and size in different localities, there may be reason to use the name given by the salters and merchants, viz, *brand K*. This herring was not good, and hardly fit for salting.

3. *Big, dry, outspawned herring.*—Also this herring was less fit for salting. It appeared already in November, and became very numerous after New Year. This herring, and also bigger individuals of the preceding form, were by salters named "*brand K K*." It corresponds to the Scotch "spent herring."

4. *Inmeat-herring*, by foreigners called "Voll hering," or "Full herring." Among them also occurred individuals that had begun spawning, *kuit-herring*. This was the only kind really fit to be salted, and when properly cured it made a superior article, which fetched $8.10 per barrel. It was branded *K K K*.

Besides these, there were also found all intermediate forms, and at the end of the season was found "inmeat-herring" of the winter and spring-spawning, "*grass-herring*."

The various kinds of herring occurred in very different proportions at different periods. Up to January 10, Nos. 3 and 4 were most abundant;

after that date, No. 2, and before, as well as after the proper season, No. 1.

Of a well-assorted lot stored at Grebbestad, and containing 2,660 barrels, 78 barrels were marked with the brand *K K K*, 1,185 barrels *K K*, 1,262 barrels *K*, 5 barrels *M*, and 130 barrels were "bressling" or sprat. As a rule, the fisheries at Fjellbacka and Sote Fjord gave larger herring than the fishery at Strömstad, and the most mixed herring was caught in the neighborhood of Lysekil, where, anyhow, the fishery was of least importance, though it lasted to the beginning of March.

The salting was not started until the end of November, when the great "inmeat-herring" appeared, and the seine-gangs sold the lodd-herring, but divided ("bytte") the "inmeat-herring" between themselves, to be salted for their own household use. Merchants salted about 400 barrels of lodd-herring for cattle food, as a speculation; but a much larger quantity of fresh herring was purchased by the farmers and salted. The whole west of Sweden knows the value of herring as cattle food, and a very large part of the catches during the month of December was consumed for this purpose. Some lots went to the compost.

On New Year's day two steamers arrived in Bowall Strand for the purpose of salting herring. The Göteborg merchants had thus started the business, and now speculation began on a large, indeed far too large a scale.

Barrels and expert hands were in great demand; ultimately, also, salt. All was procured from Norway. Not until January 11 the first ship-load of barrels arrived. On the 14th the salters were in full operation; and although the supply of herring was limited to a small section of the district of Fjellbacka, besides sundry schools south and north therefrom, nevertheless full cargoes were brought to the side of every one of the 26 steamers which, together with sailing craft and hulks, had anchored in the sounds around Florö and Dyngö on purpose to salt herring. About 20,000 barrels of herring were caught from January 13 to January 19. The following week, January 20 to 26, about 23,000 barrels were secured in the districts of Strömstad, Fjellbacka, and Kungshamn. From January 27 to February 2 about 16,000 barrels were caught, of which about 10,000 barrels in the district of Fjellbacka. From February 3 to 9 about 11,500 barrels were caught, and the same quantity in the week February 10 to 16. Of this, however, a great portion consisted of big lodd-herring, which received the brand *M*. During the last three weeks of that month the herring fishery was of trifling importance and mostly yielded lodd-herring.

As far as can be ascertained, upwards of 75,000 barrels of herring were salted on board steamers or hulks in the "Skärgård," or transported to Göteborg to be salted there; and, besides, 1,000 or 2,000 barrels were sold at the fish-market of the said city and salted by consumers. If one-third of all this herring be deducted as loss by packing and as damaged herring, the quantity of good herring obtained may safely be estimated at more than 50,000 barrels.

The treatment of the herring has not been commendable, and everywhere abroad where it was not rejected or even condemned, as was the case at Hangö, where a whole steamboat cargo of 1,400 barrels was condemned and sold at condemnatory auction at 5 cents per barrel, the article has been received with very little encouragement. Through this export the market abroad probably is spoiled for a long time, and a future herring fishery will no doubt suffer great damage from the bad curing in this year.

The principal cause of the damage was the inferior quality of the herring itself, but also to a great extent the exceedingly poor barrels.

In fact, very little has, as yet, been disposed of, for although large shipments were made to various places, still the quantity really sold is trifling, and the prices obtained have generally been so low as hardly to cover the expenses for salting and for barrels, still less to pay for the herring. From $1.50 to $2.25 in Germany and the Baltic provinces for the brand *K K*, and proportionately more or less for other brands; about the same price in Finland; at most, $2.70 in Norrland, and same price in the interior provinces, are the market prices hitherto quoted. It is to be supposed that somewhat higher prices may be obtained when the herring get riper.

The marketing of fresh herring, on the other hand, was both extensive and successful. The freight lists of the railroads are said to display large figures. The herring was sent abroad, too; whole ship cargoes went to German smokeries. The steamship Strathbey made two trips to Scotland with altogether over 3,000 barrels of fresh herring. Norwegian vessels salted and carried home 3,227 barrels during the month of January, and also in February several invoices were shipped to Norway. Swedish steamers brought 2,700 barrels of unsalted herring to Christiania.

The conduct of the population gave no cause of complaint; sobriety and peacefulness were everywhere observed.

Some confusion existed at the beginning on account of the inequalities in measurements, until it was generally agreed to adopt a measure of 5 Swedish cubic feet as the most convenient standard, being nearest equivalent to a Swedish herring-barrel.

His Majesty's Government has, under date of February 1, this year, most graciously granted the application made by the provincial government of Bohus Län December 31, 1870, that § 22 of "Regulations for the fisheries," regarding the meshes and size of herring-nets, shall be suspended until further notice in the Län of Göteborg and Bohus.

The herring fishery south of Lysekil, in the archipelagoes of Tjörn and Marstrand did not present any features indicating an ingress of sea-herring. During the fall some signs of herring were noticed off Winga, but the quantity of herring actually seen was not larger than usual. The seine-gangs went north and took part in the fishing in the districts of Fjellbacka, &c.

The value of the catches being calculated principally from the earnings of the seine-gangs, an inaccuracy has been the consequence, as 10,000 barrels have been attributed to the first district, though actually taken in several other districts. But as it was impossible to ascertain in what particular district they were taken, they have been reported for the first district with a remark.

The southern districts have supplied their hook fishery with fresh bait, and, besides, had their share of the sprat fishery.

b. The sprat fishery.—As may be seen from the tables, also, this fishery was very rich. It began as early as September, and the sprats being almost free from "ganeskar"—*i. e.*, they were very little infested with crustacea, of which the water this year was unusually devoid, on account of the cold summer, abundant rain, and prevailing land-winds—they could be utilized for canning as anchovy at an earlier season than usual. An uncommonly large quantity was pickled, and several new factories were started. About 350 barrels have been salted as "bressling," and it is obvious that the preparing of sprat gives a larger profit than the entire herring business. According to information obtained, 5,200 barrels have been pickled or salted.

The sprat fishery inside of Oroust was also very rich this year; the proceeds are accounted to the income of the sixth district.

E.—THE LOBSTER AND OYSTER FISHERIES.

a. The lobster fishery.—It cannot be denied that the lobster fishery is gradually decreasing, whether the size or the number of the lobsters caught be considered.

It is irrefutably a necessity that the time of prohibition shall be extended in the fall when the conjugation generally takes place; and also that the minimum size of lobsters allowed to be caught shall be so determined, that their first spawning be protected.

The English Parliament has lately resolved that 8 inches shall be the minimum size, and it would be well to adopt that as a law with us, too.

b. The oyster fishery.—As usual, in winter time, a quantity of rock-oysters were gathered with oyster-rakes this year.

The overseer in the fourth district has reported one hundred "trees" to have been caught within his district, but the fact is that they were gathered from several localities by fishermen living in Klöfvedal parish.

The Fishermen's Association of Göteborg and Bohus Län have, during the year, insured—

(*a.*) Sixty-three bankers	$46,794 51
Outfits to these 63 vessels	36,196 94
New insurance on outfits	3,265 79
(*b.*) Fifty-two seine-boats with outfits	15,140 93
New insurance on outfits	107 46
Total	101,505 63

The losses during the year were:

Bankers	$6,922 02
Seine-boats	965 84
Total	7,887 86

Lysekil, April, 1878.

GERHARD VON YHLEN.

Summary of statistics of the Bohus Län fisheries in 1877.

Fishery.	Crew.	Bankers.	Decked boats.	Open boats.	Tons.	Products.	Price obtained.
Great fishery	1,645	189			6,709		$253,036
Mackerel fishery	1,408		349		3,515	1,618,600 pieces	68,442
Winter fishery	1,694		98	410	2,535		67,126
Herring fishery	1,490			389	495	244,500 barrels	166,968
Sprat fishery						13,138 barrels	27,238
Lobster fishery	1,728					241,240 pieces	21,513
Oyster fishery						406 trees	2,454
Total	7,965	189	447	799	13,254		606,777

IX.—THE FIRST FIVE YEARS OF THE EMDEN JOINT-STOCK HERRING-FISHERY ASSOCIATION.

By Senator DANTZIGER, of Emden.

The close of last year completed the fifth year of an enterprise which had been started by prominent citizens of Emden in conjunction with the German Fishery Association, for the purpose of cultivating the herring-fisheries which had been carried on in Emden from time immemorial and of combining with these other fisheries on the high seas.

An attempt had been made as early as 1857 to start a joint-stock company for fishing herring and codfish with twenty-five vessels, but the buildings of the maritime association, "Harmony," were destroyed by fire that same year, and nothing more was done than to frame a constitution. This proved a blessing in disguise, for scarcely ten years later a new kind of herring-vessels, the so-called "logger," were introduced in Holland. This brought about other improvements in the herring-fisheries, so that the vessels with which the city had intended to carry on the fisheries would certainly have proved useless. Since the introduction of the "logger," in 1867, the Dutch sea-fisheries have improved considerably. The former system of premiums has been abolished, and, according to the official annual reports, the Dutch are proud of their "free fisheries," which enjoy the favor of the capitalists.

If we go back in the interesting history of the Emden herring-fisheries as far as the beginning of this century, we find that during the first decade they were suffering from those circumstances which at that time depressed commerce and navigation generally. The "buisen"—this was the name of the old-fashioned herring-vessels—do not seem to have gone out every year; the following result is, however, reported:

In 1801, 43 "buisen" caught 3,528 barrels of herring and codfish. During the second half of this decade the fisheries seem to have recovered very rapidly, and the following results are reported:

1815.	? "buisen"	3,772 bbls.	Herring and codfish.
1819.	52 "buisen"	1,848 bbls. (?)	
1820.	? "buisen"	2,757 bbls.	

The "buisen" were accompanied by two clippers, of which one had to take the first haul to Hamburg, while the other had to go to Emden. This was necessary, as the connections of Emden with the interior were

* Herr Senator Dantziger in Emden: Die fünf ersten Betriebsjahre der Emder Herings fischerei-Actien-gesellschaft, in Circular No. 4. Berlin, Mai, 1877, des Deutschen Fischerei-Vereins. Translated by H. Jacobson.

very imperfect, and remained so for a long time till the West Hanover railroad was opened in 1856. In the year 1819 a tax of 72 cents was laid on every 100 pounds of foreign herring, in order to encourage the domestic fisheries. It is possible that the results did not satisfy the Hanover government, or perhaps English influence was at work, or the premium of $216 each for 54 vessels, amounting to a total of $11,664, became burdensome to the Hanover state treasury. At any rate, the Emden people were informed that in future they could only expect an annual premium of $144 per vessel. Emden remonstrated against this measure, saying that her fishermen could no longer compete with Holland, where an annual premium of $210 was given per vessel. It was finally resolved that the Emden people must be satisfied with a total premium of $6,480. As this sum, at the rate of $216 per vessel, would only furnish premiums for about 30 vessels, one of the fishing associations, with 24 "buisen," emigrated to Enkhuizen, in Holland, in order to get the Dutch premium, while 28 "buisen" and 2 clippers remained in Emden in order to enjoy the former premium in full. In 1856, the number of "buisen" had dwindled down to six. The number of clippers was at first two, afterward three, and in 1828 even four, but after 1834 only one. The best results were obtained:

1841.—13 "buisen," with an average of 282 barrels herring and cod per vessel.

1837.—15 "buisen," with an average of 256½ barrels herring and cod per vessel.

1844.—12 "buisen," with an average of 353 barrels herring and cod per vessel.

1834.—16 "buisen," with an average of 245 barrels herring and cod per vessel.

And the poorest:

1852.—10 "buisen," with an average of 71½ barrels herring and cod per vessels.

1846.—11 "buisen," with an average of 82 barrels herring and cod per vessel.

1845.—12 "buisen," with an average of 97 barrels herring and cod per vessel.

1822.—27 "buisen," with an average of 108 barrels herring and cod per vessel.

1824.—25 "buisen," with an average of 109½ barrels herring and cod per vessel.

1848.—9 "buisen," with an average of 116 barrels herring and cod per vessel.

During the years 1833–1839, 1840–1842, 1844, 1851, and 1854 the average annual result per vessel was 200 barrels. The direct profit which the great fishers derived from the fisheries may have been small; but these fisheries always gave employment to a large number of men, boys, women, and girls; and as Emden at that time was far from the great

highways of commerce, it may be supposed that those traders who had taken contracts for furnishing fish must have made out pretty well, so that every one in Emden has favorable recollections of the herring-fisheries.

It will, therefore, be easily understood that ever since the old herring-fisheries had come to an end in 1857, wishes were from time to time expressed to have them flourish again. People were undecided, however, whether they should follow the advice of the motto over the chief entrance to the Emden city hall, *Concordia res parvæ crescunt*, or whether they were to take comfort from another motto, *In spe et silentio fortitudo nostra*, which is placed in a somewhat out-of-the-way corner near the staircase, and is not seen by every visitor of the three hundred year old building, which is an eloquent witness of Emden's former splendor. In 1871 it was at last resolved to examine the flourishing Dutch sea-fisheries. The favorable reports which had come from there were all corroborated by this examination. The German Fishery Association gave encouragement by promising to support a new joint-stock company by its influence. In the course of this winter the German joint-stock company bought of the firm of Kruthoffer & Co., in Vlaardingen, six "loggers," with everything belonging to them, and the crews which had already enlisted on these "loggers" remained faithful to the new enterprise in spite of some very violent attacks in the Dutch papers.

In May, 1872, these vessels came to Emden, whence during the following month they started out on a herring-fishery amid the cheers of the population. The head of the above-mentioned firm had been induced to become the technical leader of the enterprise. It had been his wish that a joint-stock company might be started with a capital of $216,000, he to become one of the shareholders and take one-tenth of the shares. The first payment of 40 per cent. would have sufficed to commence the fisheries with the above-mentioned six vessels. As, according to the experience of Dutch fishers, a capital of $10,800 was required for every "logger," it was his idea to make a payment of 10 to 15 per cent. every year and build 2 to 3 "loggers," till the whole capital had been paid in and a fleet of 20 vessels had at the same time been secured.

It seemed almost impossible for a city of moderate means, which had just escaped from the yoke of a second-rate state (Hanover), and had entered the Prussian monarchy with the best intentions and great expectations, to raise the necessary capital. The hope that help might come from other parts of Germany soon proved delusive, for the failures of some former large fishery enterprises were yet too fresh in the memory of the public. It availed nothing to show that these failures did not prove anything in the present case, because those former enterprises had never been engaged in the *herring-fisheries*, and an examination of the Dutch fisheries had proved conclusively that it was just the herring-fisheries which, by the introduction of many improvements, had laid the foundation of profitable fishing enterprises in Holland, and that her-

ring-fisheries should be the main object to which the new Emden enterprise was to be directed. The sentiments which unfortunately prevailed on the Berlin Exchange are illustrated by an answer, which a year later—when a second issue of shares was to be made and when the Emden company could show a good beginning—was given to an Emden delegate by the representative of a wealthy Berlin firm. Nothing would induce this man to advance some money, neither the general usefulness and importance of the enterprise nor the well-founded hope that, after a short period of struggling, ample profits might be looked for, as this domestic enterprise enjoyed the advantage of a tax of 72 cents per ton, therefore a percentage of 6–8, which foreigners did not have, nor the fact that times in Emden were not worse than in Holland. His answer was simply this: "As soon as you can prove to me that you have made a profit of 10 per cent., you can get as much money as you want."

We succeeded, however, in selling $72,000 worth of shares at par, and make the next year a second issue of another $72,000 worth, of which shares to the amount of $30,960 were sold. These sums were not sufficient to gradually enlarge the enterprise, and this was the hope which was continually held out to the director, who had no fixed salary, but only 20 per cent. of the net profits, and who, if no hopes had been held out to him, might have resigned his place very soon. All this, of course, proved a continual source of trouble.

The results of the first two years, however, were very satisfactory, although we had to confine ourselves to the herring-fisheries, and had to be satisfied with rented buildings which lay inconveniently scattered. The first business year, comprising eight months, yielded a dividend of $1.98 per share, the payment on each share having been $50.40. All the regulations were strictly observed, and the reserve-fund was not forgotten. During the second business year, comprising twelve full months, of which, however, only nine, from June to November, had been devoted to the herring-fisheries, the number of vessels was increased to nine, and the shareholders received a dividend of $2.16 per share.

In order to fulfill the promises made to the director, three new "loggers" had to be built (these were the first built in Germany), and it had become necessary to contract a loan. Even these first two years having yielded small profits, there were reasonable hopes of obtaining better results in the future, as the buildings which had been constructed with a special view of facilitating the business had meanwhile been finished. A favorable location close to the harbor had been bought from the city for a cheap price; a track had been laid from the harbor to the railroad depot, passing between the two main store-houses; six convenient piers had been constructed. Each of the two store-houses, measuring 90 feet in length, has a good cellar, one for salt, the other for storing, packing, and sorting herrings. Above these cellars, on a level with the cars, there are two rooms, inclosed on three sides but open on the side facing the track. These rooms are connected by a small draw-

bridge, and the one above the packing-cellar has a trap-door leading down to it. In the northern store-house there are, on the same floor, the office of the association and a room for storing provisions. In the southern store-house there is at one end the dwelling of the store-house keeper, and at the other end a room for tools and materials. An outside staircase leads to the large second-story room, where about 20 women and girls are busy all the year round mending nets. Above this room there is a large garret-room, where different materials for the nets are prepared. This gives constant employment to several men. In the northern store-house a staircase leads to a large room in which the nets are kept during winter. This room has no windows, but blinds, which are opened in dry and closed in wet weather. The garret-room has twelve compartments, in which the sails, cordage, &c., of every vessel are kept separate. The net-store-room is, by a bridge, connected with the net mending room. South of these two store-houses there is a large wooden shed for storing staves, hoops, and barrels; north of this shed there is a stone building, containing the coopers' shop. A well 170 feet deep furnishes good water for providing the vessels with drinking-water and for making the finished barrels tight. In the eastern corner of the lot there is a tanning establishment. The catechu is kept in a closed space; in the walls of this space there are two copper kettles in which the catechu is dissolved in hot water; from the kettles it is by pipes conveyed to two square cemented holes in the ground, in which the nets are tanned. These holes have a roofed building over them, which, however, is open on three sides. The upper edges of these holes have rollers, so the nets cannot be injured in taking them out. The tannery building likewise contains the modest dwelling of the tanner. Near it there are long rows of poles on which the nets are hung up to dry. For drying those nets which have been used a narrow strip of land extending along the harbor has been rented from the city. There is nothing to hinder the increase of the lot to double its present size, as the ground bordering on it only contains a small house used for no particular purpose, and is owned by the government. It is probable that no Dutch establishment combines as many advantages as the Emden one.

The chief centers of the herring-fisheries are Vlaardingen and Maassluis. These are located on the river Meuse, but they are not on a railroad. The total cost of the new buildings, the tracks, fences, paved sidewalks, 6 piers, and well, has not exceeded $20,000; which is certainly so small a sum that it would have been difficult to put up the same establishment at such a price in any other city.

With all these favorable conditions, it seemed altogether incomprehensible that after two successful years a comparatively large number of nets were lost, and there was a very sudden decrease in the number of fish caught during the year 1874. Everything, however, had been so well regulated that a dividend of $1\frac{2}{3}$ per cent. could have been declared if it had not become necessary to reserve all the profits; as some

of the crews demanded higher wages, which the association could not grant, and even went to law about it. The issue of this lawsuit, which is still pending, is not doubtful, as the decision of the inferior court was unfavorable to the association.

The chief cause of all this must be found in the tendency to strike, which is unfortunately so common in Germany, and which had also spread among the otherwise steady workingmen of Eastern Westphalia, Oldenburg, and the Lippe principalities. The result of the strike was that the crews received, besides their wages, a certain percentage of the fish caught by them; this, however, was only granted by the association on condition of strict obedience and good behavior. These conditions must of course be filled to the letter, while the crews thought they could ignore them, and appropriated considerable quantities of herring under the pretext that they were allowed to make presents to their relatives. Although there was no provision made in the "rules and regulations for sailors" for such a percentage, the inferior court held the opinion that one of the above-mentioned regulations applied in this case, which provided small fines for offenses of this kind. Of late, the relation between the association and the crews has become more amicable, and the time does not seem to be distant when the crews will be allowed a certain clearly stated percentage of the fish caught by them.

In order to ascertain this percentage, sales are held immediately on the arrival of the vessels at which the association itself becomes a buyer when the demand is not very great and the prices consequently low. Of these prices a deduction is made for barrels and 3 per cent. for the dividend; and the crews then receive the following percentage:

	Per cent.
1 captain	4
1 mate	$2\frac{1}{2}$
8 sailors @ 2 per cent	16
2 sailors @ $1\frac{1}{2}$ per cent	3
1 sailor @ 1 per cent	1
1 boy @ $\frac{3}{4}$ per cent	$\frac{3}{4}$
1 boy @ $\frac{1}{2}$ per cent	$\frac{1}{2}$
15 men	$27\frac{3}{4}$

During the first two years, the captains, according to their assiduity, skill, and good luck, made from $200–$300, besides their board and lodging; which was quite a good sum for five months' service. During the three years, 1874–1876, the other members of the crew received very good weekly wages instead of their percentage; although not as many fish were caught as during the preceding years, especially in 1875 and 1876, when not half as many were caught as in 1872 and 1873; so that the crews have always made a very decent living.

Meanwhile a change of directors had taken place in 1875. The new

directors soon made the startling discovery that an ominous mistake had been made in *the management of the nets.* These represent a capital of about $3,750 per vessel, or $45,000 for 12 vessels—or rather $41,250 for 11, as, unfortunately, one vessel had been lost in 1875. As there are otherwise no very great expenses in carrying on herring-fisheries, the chief point coming into consideration is the question of the nets.

The nets were formerly knit by women and girls, and the material employed also for the herring-nets was hemp. This material has now been almost universally superseded by cotton, which is cheaper and more pliable; and the nets are now made by machinery. In Holland and Great Britain, and also to a great extent in France, the cotton nets are made at least as strong as the former hemp nets by repeated tanning with catechu, alternating with a soaking in linseed-oil. This soaking requires considerable attention in order not to break the nets, of which there is danger if the drying, which must follow the soaking in linseed-oil (the superflous oil is removed by pressing the nets between rollers), is not done evenly. It was thought that this could be avoided by not soaking the nets in oil; all the more, as in 1872 several French fishing associations had adopted this method, and, as reported, with satisfactory results. This is not impossible, as the circumstances in France are somewhat different. The French herring-fisheries are nearly all coast fisheries in the channel; the voyages are shorter and the nets are more frequently exchanged. Other French reports, however, say that the method of tanning and oiling is to be preferred in spite of the greater expense. The fishermen of the Emden association say they have repeatedly warned the members not to omit the soaking in oil, but in vain. When the present director, in 1875, accompanied the "loggers" on their first voyage in a clipper he had similar misgivings, and his long experience as a sea-captain enabled him to understand the whole matter when, during this voyage, the fishermen told him their views regarding the soaking of the nets; but during the fishing season nothing could be done, and when the sea was not very rough the evil consequences of omitting the soaking were not seen. Even the second voyage gave no indication of the terrible failures which were to follow so soon; but the third and fourth voyages, in 1875, exhibited an almost uninterrupted series of losses, the nets being either partially or totally broken, so that but very few fish were caught. This is certain, that only the right degree of soaking will give to the nets that elasticity and power of resistance which is required for long voyages, such as the Emden herring-fisheries involve. As the tanning makes the nets loose they will, when piled up high in the narrow hold of the vessel, be compressed into a compact mass by their own weight. A great degree of warmth is developed, actually increasing to heat, especially when the nets come wet from the water, and cannot be aired on account of continued rain-storms; and, as in wet hay, a burning process does finally take place. The association even now owns nets which are five and six years old, and

are as useful and as strong as new nets. But the most important quality of oiled nets is this, that the meshes open better, and that consequently they catch the fish better, for the herring is caught by passing its head so far into the meshes that it hangs fast by its gill-fins.

As a sort of excuse for the failures of 1875 it was said that the factory which had done the tanning had used gamboge instead of catechu, in order not to tan the nets too strongly, which, however, had had the consequence of giving the nets a lighter color, making them more visible to the fish in bright nights. Even if both of these assertions were correct this would not prove the advisability of omitting the soaking in linseed-oil.

The whole series of nets must be imagined as a wall fully 6,000 feet long and 48 feet high, representing, therefore, a flat area measuring 300,000 square feet. It is kept in the water in a perpendicular position by having pieces of cork on the upper and pieces of lead or stone on the lower edge. The nets are fastened one behind the other by hemp lines to an inch-rope called the *speerreep*. On this *speerreep* there are also fastened the so-called "seisings," strong lines about 42 feet long, which at a distance of about 42 feet are fastened to the *fleethreep*, a rope of the thickness of an arm. At the end of the *seisings* the buoys are fastened which keep the *fleethreep* floating at a depth of about 18 feet. The *fleethreep* extends far beyond the first net and connects the vessel with the nets. The upper edge of the nets is therefore fully 40 feet below the water, while the lower edge is 90 feet below. The whole "series" consists of sixty-five nets, and as each net has 216,000 meshes, we get the considerable number of 14,040,000 meshes for the whole "series." Besides these, each vessel has sixty-five reserve nets, so she can start with fresh nets 2–3 days after having reached the port. If everything is in order a vessel sometimes catches in one night 100–120 barrels, *i. e.*, 70–80,000 herrings. It is no rare occurrence that a "logger" catches a full cargo (280–340 barrels) in 10–12 succeeding nights. Although, therefore, the expenses of fitting out a herring-fleet are considerable, there is a good chance of making fine profits. The amount of these profits depends, besides on good luck, on the skill and assiduity of the crew. The managers on shore can, especially when they have sufficient funds at their command, save many a dollar by prudent management, but their influence does not reach as far as the actual catching of the fish.

The most important point is, under all circumstances, the treatment of the nets, and this should be done according to certain well-defined rules. Experience has taught that it is best for the success of the fisheries if *not more than one-third of the nets* has to be renewed in one year. One may be contented if no more are lost by tearing or by a total loss in stormy weather. If we count the total number of nets required for the Emden fisheries $65 \times 11 \times 2 = 1{,}430$, we would consider 450–500 nets as about the average number needed annually. Experiments made on

a small scale had proved that by omitting the soaking in linseed-oil \$2.50–\$3 could be saved per net. The total saving per year would therefore be \$1,250–\$1,500—truly a small item compared with the risk of ruining the whole fishery.

The present board of directors would gladly have changed the method of treating the nets as early as 1876, and commenced a new era in the history of the Emden fisheries, but their funds were not large enough to do this, and it also proved at that time a technical impossibility. The attempt to soak the nets in oil long after they had been tanned proved a failure, and was only successful with those nets which had not yet been used in fishing. All that could be done was to get 800 nets prepared according to the Dutch method, to examine the old nets frequently, and use the best of them by adding them to the lower portion of the "series." With such nets only very moderate results could be expected in 1876, and even these were dependent on fortune's favor, which, we are sorry to say, deserted the fisheries in that year. The year 1876 will always be mentioned in the history of the herring-fisheries of all nations as one of the most unfavorable years on record, because the herrings came later and in smaller numbers than usual. The Scotch caught one-third less than during the preceding year, and the Dutch, French, and Norwegians did not fare any better. The fact that the reports of the herring-fisheries in 1876 mention considerable losses must not, however, be considered as an indication that the herring-fisheries could never be profitable again; but the different unfavorable circumstances which combined to bring about this result must be taken into account. It is encouraging at any rate to know that the decrease was one-half less than what it was in 1875. The chief cause of the losses which the Emden association experienced in 1876 was the extraordinarily large number of new nets which had to be bought. In 1877 the association will begin the fisheries with entirely new and good nets.

All we have said hitherto will enable our readers to understand the statistics of the last five years. In giving them we have for perspicuity's sake avoided to give the data too much in detail, which, considering the smallness of the whole enterprise, might easily lead people to make wrong conclusions:

Year.	Total No. of ships.	First voyage.			Second voyage.		
		No. of ships.	Result.		No. of ships.	Result.	
			Bbls.	Dollars.		Bbls.	Dollars.
1872	6	6	689	9,265	6	1,307	12,165
1873	9	9	1,190	14,319	9	1,832⅓	18,846
1874	12	12	1,009	13,240	12	2,269½	22,290
1875	11	11	1,202	14,937	11	1,675	17,633
1876	11	11	571½	9,270	11	1,493	19,481

Year.	Total No. of ships.	Third voyage.			Fourth voyage.			Total.		
		No. of ships.	Result.		No. of ships.	Result.		No. of ships	Result.	
			Bbls.	Dollars.		Bbls.	Dollars.		Bbls.	Dollars.
1872	6	6	1,410	12,221	6	379	3,294	24	3,785	36,945
1873	9	9	1,885	19,372	7	570½	5,711	34	5,478	58,248
1874	12	12	2,137	20,068	10	186½	1,813	46	5,602	57,411
1875	11	11	343	3,717	......	....	....	33	3,220½	36,287
1876	11	10	1,080	13,198	1	29½	363	33	3,174	42,312

Year.	Total No. of ships.	Average result per ship.					
		First voyage.		Second voyage.		Third voyage.	
		Bbls.	Dollars.	Bbls.	Dollars.	Bbls.	Dollars.
1872	6	115	1,544	218	2,027	235	2,037
1873	9	132	1,591	204	2,094	209	2,152
1874	12	84	1,103	189	1,857	178	1,672
1875	11	109	1,358	152	1,603	31	338
1876	11	52	842	136	1,771	108	1,320

Year.	Total No. of ships.	Average result per ship.				Average per voyage.		
		Fourth voyage.		Total.				
		Bbls.	Dollars.	Bbls.	Dollars.	No. of voyages	Bbls.	Dollars.
1872	6	63	549	631	6,157	24	158	1,539
1873	9	81½	815	608½	6,652	34	161	1,713
1874	12	18½	181	467	4,813	46	122	1,248
1875	11	....	....	292	3,299	33	97½	1,099
1876	11	29½	363	288½	4,296	33	96	1,032

The reason why the average results of the fourth voyage fall so far short of those of the second and third is not only that large hauls of fish are not very frequent during the second half of October and during November, but also that the stormy weather which often prevails during these months occasions great losses of nets. If a ship loses her nets, she may occasionally—this has also happened to some of the Emden ships—return without having caught anything. Such failures will of course make the average lower, while it would be higher if we were to count only those voyages on which anything is caught. The "logger" which was lost during the fourth voyage in 1874 has been counted in our statistics.

With the exception of losing nets, the Emden "loggers" have been very fortunate in being preserved from accidents. One of the "loggers" ran ashore on one of the Shetland Islands in 1876. It was got afloat again but had to lie in Lerwick several weeks to undergo repairs, and thus lost one voyage. This was the only case in which an Emden "logger" has only made two voyages during a season. In former times the "buisen" (the old vessels) only made one voyage, rarely more than

two, but the average number of annual voyages of the quick-sailing and practically built "loggers" ought to be four.

The year 1875 ranks lowest as to the average results; 1876, in spite of the general failure of the fisheries in all countries and the still prevailing lack of good nets, shows a little advance. For, although 47 tons less were caught, the sum realized exceeded that of 1875 by $6,025. But the most important indication of an improvement in the fisheries in 1876 may be seen in the fact that in 1876 the result of the third voyage was a great deal more favorable than in the preceding year, one vessel at least returning in time to undertake a fourth voyage. The main profits of a season are in the third voyage; the results of this voyage are the criterion whether a season has been favorable or unfavorable. Extraordinary results such as occasionally occur in Holland, as for instance, one of the Vlaardingen "loggers" once caught 1,400 tons—have not been obtained by any Emden vessels. None of these has made more than four voyages during the season, while among the large number of herring-vessels which leave the Dutch ports every season there are always some which make 5–6 voyages. These, however, generally catch many small fish which are not very highly esteemed in Emden.

Long since, however, certain measures have been introduced in the management which will save a good deal of money, so that in future a result of 500 tons per ship will be sufficient to make some small profit. But as during the first two years the average per ship has been 631 and 608½ tons, some having caught 800 and more, it is to be hoped that in the future our average results will not fall far short of the Dutch. These according to the official reports obtained the following results during the last five years:

1872, 64 "logger" @ 716½ bbls.;
1873, 68 "logger" @ 975 "
1874, 83 "logger" @ 695 "
1875, 88 "logger" @ 589½ "
1876, 94 "logger" @ 540 "

or an average of 686 bbls. per vessel and per year.

The details on which this calculation is based—to give which would lead us too far—give an interesting insight into the varying results of the Dutch herring-fisheries. Those associations which secured an average success numbered 10–18 vessels. Extraordinary results were mostly obtained by smaller associations. One of these follows the same principle as the Emden associations, viz, to order nets with the largest possible meshes. The poorest result for years has been that of a Harlingen association owning only one "logger"; this poor result has also in some measure been due to the great distance between Harlingen and the two chief herring-ports Vlaardingen and Maasluis. In the fisheries there is always something new to be learned, and the smaller they are the fewer will be the new experiences. The fact that the number of Dutch "log-

gers" has in five years increased from 64 to 94 proves that the Dutch herring-fisheries must have been successful (although during the last year there have been complaints that they were not as flourishing as formerly), and also that the strong and elegant vessels called "logger" are the most suitable for carrying on the herring-fisheries, or are at any rate considered so in Holland.

Whatever the individual results may be, the following facts will speak for themselves: From 1858–1871 there was in Emden some trade in fish, which were brought by vessels from Norderney, Borkum, and Pesum, occasionally also by vessels from the Elbe and from the British coasts; but the expeditions fitted out by the new association undoubtedly have brought new life into the Emden trade. During the last five years the Emden vessels have all in all made 169 voyages, and brought home a total of 21,259 barrels of herrings. The total sum realized from the fish-auctions has been $231,208; and on those fish which the association bought there was a further profit of $21,151, so that the total sum realized was $252,359, which may certainly be called the reward of home activity, all the more gratifying when we call to mind the former tribute which Germany paid to foreign fishing associations by buying their fish.

The Emden association has at all times paid special regard to bringing a good quality of fish into the market. The best proof that the Emden herrings are held in high esteem by their steady customers is found in the average price which they fetch; the average price per barrel was $10.67 in 1872, $11.53 in 1873, $11.30 in 1874, $12.42 in 1875, $14.30 in 1876.

This gradual increase to fully one-third corresponds to the rise of prices in the Dutch and Scotch markets, which have always exercised an influence on our markets. But I believe that there is not another association, not even in Holland, which can command as high prices as the Emden one, and which without employing any artificial means can furnish such a delicately flavored herring. The association seeks an honor in upholding the old reputation of the city of Emden, by handling and sorting the fish very carefully. Classed according to quality we get the following results in barrels:

	1872, 6 vessels.	1873, 9 vessels.	1874, 12 vessels.	1875, 11 vessels.	1876, 11 vessels.	Total.
1. "Maatjes" herrings	27½	61	47	14½	14	164
2. "Full" herrings, first quality	3,036½	4,622	3,797½	2,813	2,725	16,994
3. "Full" herrings, second quality	92	91½	1,112½	75	46	1,417
4. "Ihlen" herrings	199	240½	102½	140	156	838
5. "Wreck" herrings	358½	355	415½	122½	95	1,346½
6. Smoked herrings	63	51	75	....	30	219
7. Mackerel	....	6	1	11	7	25
8. Codfish	8½	51	51	44½	100½	255½
Total	3,785	5,478	5,602	3,220½	3,173½	21,259

"Maatjes" herring are those herring which are just entering upon their sexual development. They are at the beginning of the season

caught in small quantities. They have a most delicious flavor, and are not salted very much, because they are sold very rapidly. A barrel of "maatjes" contains about 1,000 fish.

"Full" herrings, first quality, are fish whose sexual organs are fully developed, and are at the same time the fattest of all herrings. The association have them sorted in "large" and "small" ones, and there are generally three-fourths of the former to one-fourth of the latter. A barrel of large "full" herrings contains about 700 fish, and a barrel of small ones about 900.

"Full" herrings, second quality, are those which in Holland are called "knitziek", that is, ripe, and are not quite as fat as the before-mentioned kind.

All "full" herring must be well salted, and, if kept properly in brine, retain their delicate flavor for years. Here it is where a mistake is often made, especially by buyers of small quantities. As soon as a barrel is opened and some of the fish taken out, an empty space is created. This space ought to be kept filled with brine up to the lid, which ought to be pressed down by some heavy weight. This brine is easily procured by dissolving coarse salt in hot water until the water is thoroughly saturated with the salt. This brine must, of course, not be poured over the fish until it is quite cold. If this simple procedure is omitted, there will invariably be some fish with an impure or oily flavor.

"Ihlen" herring are those from which the milt or roe has been taken. They have a pure flavor and a large size, but are mostly lean or dry. This kind is well suited for pickling, and is always considerably cheaper than the "full" herring.

"Wreck" herring are those fish which have been a little damaged by the leaking of the barrels. Whenever this is the case some of the brine is lost, and as soon as herring is too long without brine it gets an impure, oily flavor. On the arrival of the vessels every barrel is, therefore, carefully examined. While at sea, the barrels are filled up for the first time a few days after the fish have been caught. This is done a second time on shore, so that 17 barrels packed at sea are equal to about 14 barrels of so-called "merchants' packing." In packing the barrels the men themselves exercise a strict mutual control, and on shore there is a man specially appointed for superintending the packing. "Wreck-herring" is gladly bought by the poor inhabitants of the coast on account of its cheap price, and because, as a general rule, a large portion of the contents of a barrel consists of very good fish.

The great advantage of the Emden, and also of the Dutch method, over the Scotch method does not only lie in the more careful sorting of the salt herring (the common name of all the above-mentioned kinds), but also in the fact that the fish are killed as soon as they are taken out of the net, and are immediately, on board the ship, salted down in barrels, while in Scotland all this is done on shore. (The fish which are caught during the night are piled up high in the middle part of

large open boats, which reach the shore some about noon and others toward evening. The fish is then half dead, and is, moreover, not killed, cleaned, and packed till the following day. It is therefore softer, has not such a pure flavor, and does not keep as well as the Emden and Dutch herring.) If a very large number of fish is caught, it is impossible for the crew to kill and salt all the herring on board. Such fish which are not killed and salted till the next day are called "over-night herring," and are considered an inferior quality.

Smoked herring.—If the last haul made immediately before returning is so large that all the barrels are filled, the remaining fish can, of course, not be packed on board, but they are, with plenty of salt between, stowed away in every vacant corner of the ship, frequently filling even some of the berths. These loose herrings are in Holland called "Steurheringe". After the vessel has arrived in port, they are well soaked in water and are smoked over the smouldering refuse of oak wood, and are then brought into the market as smoked herring; an article whose excellence has so far not been fully appreciated in Germany.

The tender mackerel is as large as a full-sized herring, and is so voracious an enemy of the herring, that it often swallows young herrings. The mackerel is likewise smoked and has as delicate a flavor as the smoked herring.

In Emden they make a distinction between the codfish proper and the tough, so-called "koolfish," which latter is sold separately. Both have a weight of 8–12 pounds, and are, owing to their voracity, easily caught with a hook and line. Their favorite food, a herring, is generally used as a bait. The catching of these fish forms the private amusement of that part of the crew which is on guard. The meat of the codfish is soft and white; it is cleaned on board and salted in barrels; it is then called "laberdan". The throat and lips, being the tenderest parts of the whole fish, are packed separately in small kegs. This delicacy is so much sought after by the inhabitants of the coast towns, that it scarcely ever comes in the foreign market. The gills of the codfish are likewise put up separately, are then called "kibbling," and are considered a great delicacy. The "laberdan" is not much appreciated in Germany, because people do not know how to prepare it. It should be soaked for 2–3 days, and the water should be changed repeatedly. It should be placed over the fire in cold water, and kept boiling for 3 hours. Care should be taken that the water does not boil over. If these rules are not observed carefully, the fish is hard and dry when it comes on the table.

It may be said that, as a whole, the Emden herring-fisheries are now in a fair way to enjoy a long-continued season of prosperity. About 250 hundred-weight of old nets which have been sold recently may be termed a landmark designating a new era in the fisheries. But although the question of the nets is a very important one, it is self-

evident that its solution alone is not enough to insure the future of the enterprise.

The second difficult question is that of the crews, and this cannot be solved by the herring-fisheries alone, as these commence about the middle of June and end during November, so that vessels and crews only have employment for 4½–5 months. In starting the enterprise, it was positively the intention to keep the vessels and crews occupied the rest of the time by other fisheries on the high seas. But when the herring-fisheries during the very first season had yielded unexpected profits, which justified the managers to expect greater profits in the future, the idea of winter-fisheries was placed in the background. Of the six "loggers" bought in Holland, the three older ones had a so-called "bünne" (well). This is a square space in the center of the vessel, occupying its full breadth at the bottom; a narrow entrance leads to it, and small holes in the bottom of the vessel admit sea-water. In this space fish may be kept alive for several days, and will, of course, fetch a higher price in the market than dead fish. It has been objected to this mode of preserving fish alive that experience has shown that fish which are kept in this well grow lean and have actually lost 15 per cent. of their former weight, so that it is better to kill and clean the fish on board and keep it fresh on ice. It was well known that the first manager of the enterprise who had carried on winter-fisheries on his own account had never made much by them; but even he declared that under favorable circumstances the winter-fisheries might be made profitable. It would, therefore, have been the proper thing, during the winter following the first herring season to attempt line-fishing on one of the "loggers" having a well, to catch codfish, or in company with another "logger" to begin fishing with drag-nets, even at the risk of diminishing the yield of the herring-fisheries to some extent. But even those members of the board who took a special interest in the winter-fisheries did not deem it advisable to urge the matter until the whole enterprise had been established on a sound basis. The funds at their command were not sufficient to carry on even the herring-fisheries alone in the most profitable manner.

As regards line-fishing it was well known that the lamprey (*neun auge*) is the best bait. This fish has the good quality that it shines longer after death than many other fish. The lampreys are kept alive in small tanks whose lids have holes to admit fresh air; they are cut in oblique pieces and put on the hook. For many years, however, it has been so difficult to obtain lampreys, and their price has risen so much, that to use them as bait would have meant a positive loss. The question was, therefore, likewise discussed whether the example of the Norderney sloops should be followed, which use worms or shrimps as bait. But the entrance to the Norderney channel was not without danger to the "loggers," which go about nine feet deep in the water. The "Vitschbalge" channel, near Borkum, has a still more dangerous en-

trance; and the thought of reviving the fisheries of this island cannot be entertained unless a good harbor, or at least a breakwater, is made in its south coast which is quite close to the deep Ems channel. Negotiations were for some time carried on with the inhabitants of the island of Juist, who offered for a small remuneration to bring the full nets in the "Memmertbalge" channel on board the vessel. The roadstead, however, is quite a distance from the island; and then a roadstead is no harbor, and frequent interruptions could not well have been avoided. Another objection to line-fishing is this, that it requires from ten to twelve men, and that therefore the expense for wages and board would exceed the profits.

Fishing with the drag-net or trawl-net is considerably cheaper, as no bait is required and a crew of five or six men would be sufficient. Some of the Dutch fishermen say that during some winters they have realized a small sum from such fisheries. Inquiries made in England make these assertions very doubtful, as the sails used on the herring-vessels only permit the use of a very small trawl-net. Experienced English fishermen, however, thought that if a "logger"—which, in spite of its graceful shape, is a very solid and strong sort of vessel—got more ballast, and another foremast with all the sails belonging to it, it would make just as successful a trawler as the largest English smack—a cutter having a small mizzenmast—and that it would certainly pay to transform a "logger" in the manner described at an estimated expense of $1,500. This might have been done during the winter 1874–'75, but was delayed on account of lack of funds, and with the hope that successful summer-fisheries would bring some money into the treasury, or at any rate improve the credit of the association. But as this hope was not fulfilled, the misfortunes of 1875 shaking the credit of the association to its very foundation (with great trouble a loan of $8,750 was negotiated, enabling the association to continue the fisheries), the association gladly accepted an offer made by five of the largest shareholders to venture an attempt if 1–3 "loggers" were during three winters placed rent-free at their disposal.

After the negotiations had been carried on for many weeks, an arrangement was made which was very satisfactory to the association, as their presiding board was intrusted with the management of the whole affair. They had to do this without any remuneration, to which they agreed cheerfully, as it was in their own interest to encourage the enterprise, and as all the experience gained by it would eventually prove profitable to them. The "logger" Oldenburg, with a select crew, was sent to Hull, and was in January, 1876, fitted out there. After the foremast with all the cordage and sails belonging to it had been removed, a firm mainmast, able to resist the winter storms, was put in position near the middle of the vessel and furnished with entirely new cordage and sails. The mizzenmast remained as it was, and a new Hull invention, a patent cap-rope, which could be placed in four different positions,

completed the arrangement on deck. Below deck most of the partitions were removed and were so arranged that they could easily be put in again in spring and removed in autumn. Then ice-rooms were made likewise so arranged that they could easily be put up and removed Finally a trawl-net of the largest size was procured, as also a second or reserve net, which was constructed in the following manner: At both ends of a 50-foot pole made of oak or beech, strong iron shors resembling the runners of a sleigh are fastened, which keep the pole about three feet from the ground; to this pole the upper edge of the rolled-up net is fastened. The large net resembling a sack is made of hemp and has wide meshes; it ends in a point, near which there is a valve, through which the fish can be taken out conveniently after the net has been hauled in. The fish are killed and cleaned on board and carefully packed in layers of ground ice. By means of a rope fastened to the trawl-pole, which is tied to the fore part of the vessel, the "logger" drags the net along the bottom; successful fishing is, of course, dependent on a sufficient quantity and strength of sails. The ship is guided by another rope fastened to the stern, and it sails against the current. When fishing for plaice fewer sails are required, and the ship sails slowly with the current. In this manner the Elbe vessels generally fish; but plaice can only be caught in the latter part of spring, as only at that season they have a truly delicate flavor.

The transformation of the Oldenburg has proved an entire success. The expenses, however, amounted to almost $2,250, including the cost of a journey to England undertaken by the director, and the high wages and board of an English fisherman to serve as instructor. In future the expense of fitting up a "logger" for winter fishing will only be $1,500–$1,750. The Oldenburg made five voyages to Hull, which, not considering small unavoidable repairs, proved successful, as the fish were quickly sold in the large Hull market. The English buyers paid the highest market prices for these fish, which had been carefully handled and came to market in good condition. During the return voyages to Emden the nets were likewise let down several times, and the fish caught sold in Emden at public auction. The result of these voyages has been as follows:

Kind of fish.	First voyage.		Second voyage.		Third voyage.		Fourth voyage.	
	Quantity.	Price.	Quantity.	Price.	Quantity.	Price.	Quantity.	Price.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1. Haddock	7,490	$180 25	6,300	$187 00	10,850	$338,00	5,180	$126 00
2. Plaice, &c	1,567	40 25	1,316	24 00	1,470	28 75	2,100	38 75
3. Codfish, &c	1,260	31 00	660	18 50	300	14 25	90	4 50
4. Turbot, &c	35	4 50	5	1 25	129	19 50	207	21 00
5. Whiting	154	3 50	350	9 00	273	8 00		
6. Sundry		5 50		6 00		3 75		
Total	10,560	265 00	8,631	245 75	13,022	413 00	7,577	190 25

Kind of fish.	Fifth voyage.		Return voyages.		Total.	
	Quantity.	Price.	Quantity.	Price.	Quantity.	Price.
	Pounds.		*Pounds.*		*Pounds.*	
1. Haddock	6,300	$81 50	1,400	$22 00	37,520	$933 00
2. Plaice, &c	2,450	41 00	480	15 75	9,383	188 50
3. Codfish, &c	30	75	20	25	2,360	69 25
4. Turbot, &c	160	11 25	94	7 00	630	64 50
5. Whiting	....	....	....	....	777	20 50
6. Sundry	....	2 00	....	....	(?)	17 25
Total	8,940	136 50	1,994	45 00	50,670	1,293 00

The fish found a very ready market in Hull, and the vessel could regularly start on another voyage on the second day after its arrival. The voyages lasted:

First voyage, from January 31 till February 10 .... 11 days
Second voyage, from February 12 till March 6 .... 24 days
Third voyage, from March 8 till March 27 .... 20 days
Fourth voyage, from March 29 till April 17 .... 20 days
Fifth voyage, from April 19 till May 8 .... 20 days
Return voyage, from May 10 to May 20 .... 11 days

Total .... 106 days

If one takes into consideration that the men had a good deal to learn, it may be presumed that experienced men will during the period from February till the middle of May—the last voyages were always the least profitable ones—make one to two voyages more, and catch more fish; three or four voyages more can be made at any rate, if the vessels are fitted out immediately on their return from the herring-fisheries and can begin the winter fisheries in November or latest in the beginning of December. The English smack-fishers have had a series of very profitable years, and new vessels have every year been added to their fishing fleet, whose number was only limited by the consideration in how far the increase of the coast population could supply the necessary crews. The markets are but rarely glutted to such an extent that the fish could not be sold. The prices, of course, vary according to the quantity brought into the market, and the Oldenburg was not fortunate in meeting high prices. The months of December and January, which in most years are particularly favorable for the sale of fish, were lost to our vessel during the winter 1875–'76. Comparisons instituted between our results and those obtained by English vessels during the same period have proved that the Emden "logger," with an outfit for winter fishing such as the Oldenburg has got, can obtain the same results as large English smacks. A competent judge estimates the average annual sum realized by the Hull and Grimsby smacks at $5,000, the smaller half of which falls to the months May to October and sometimes to November, and the larger part, about $3,000, to the remainder of the period during which the winter fisheries are carried on.

The summer fisheries are chiefly carried on south of the Dogger bank, more or less near the German coast. During summer calm nights often oblige the vessels to lie still. Associations are therefore formed for carrying on these fisheries in common. A smack or a rapidly sailing clipper takes all the fish to market and returns with ice, provisions, &c. A special company owning five steamers supplies the London market in this way. The fishing-fleet, consisting of several hundred vessels which these steamers serve, carries empty boxes in which the fish are packed on board between layers of ice. To transmit these boxes while at sea is especially during winter difficult and dangerous. During that season each vessel prefers to fish on its own account, and take the fish to market. In November they begin to fish some degrees north of the Dogger bank, gradually going farther south. This explains the fact that during the winter months the small German fishing-vessels which dare not venture far from the coast do not catch many fish. If Germany, therefore, wishes to be entirely independent of foreign countries with regard to her supply of salt-water fish, it can only be done by fitting out "loggers," for they are just as good vessels for high sea fishing as the English smacks, carry the same quantity of sail, and are just as strong.

All reports agree that the most profitable season for the English smacks is from December to April, and that the unfavorable results of the other months are thereby counterbalanced; yea more, that this season has contributed its share to the prosperity of a number of English ports, such as Hull, Grimsby, Yarmouth, Lowestoft, &c. It is a fact that during winter the sum of \$400–\$600 is realized as a rule at every voyage of 2–3 weeks, and that a sum of \$900 per voyage is no rare occurrence.

As in Germany crews cannot be gotten as cheap as in England, where two men and three boys compose the whole crew of a smack, the "logger" can of course not obtain the same brilliant results during the winter fisheries as the English smack; but this is not required either, because the herring-fisheries prove a sufficient source of profit to the Emden "logger." As our "logger" loses several weeks by its voyage from Emden and back to the fishing-grounds near the English coast, it will not realize more than \$2,500 during a winter, while the smack will during the same time realize \$3,000. The experience of the Oldenburg has shown that of the sum realized from \$1,500 to \$1,750 have to be counted off for wages of crew, repairs, &c. Several winters must pass before any reliable calculations can be made.

The last winter, 1876–'77, has been an unlucky one for the English smacks, and the three Emden "loggers," have unfortunately had the same experience. After the three vessels had by dint of enormous exertions been fitted out for the winter fisheries by the middle of December, and every one hoped that toward Christmas and New Year they would share in the brilliant results of that period, they had like the English vessels to meet the most terrible storms. One of the mates lost

his life, all the vessels were damaged, and during a long voyage caught scarcely any fish.* Later the Oldenburg took a good many fish, while the other two Emden "loggers" only caught few. Competent men in Hull have expressed the opinion that the two "loggers" did not carry enough sail. It would be foolish, however, to abandon the whole enterprise on this account. All maritime enterprises have to go through similar experiences, and they only go to prove that the average sum realized by the winter fisheries would have to be calculated at $2,000–$2,250 instead of $2,500, and the average expenditure at $1,750–$2,000, instead of $1,500–$1,750. Even with such small profits, one important end would have been attained, viz, to give occupation to the crew all the year round without having to spend any extra money.

The Emden enterprise had from the very start an advantage over the high sea fisheries of Hamburg and Bremen by always having a sufficient number of men. As soon as the amount of wages had been definitely settled, as well as the manner in which they were to be paid, plenty of men could be had. But there was a constant coming and going, especially of those who possessed some nautical experience. If once this stock of the crew—perhaps one-third of the fifteen hands per "logger," which are required for the herring-fisheries—has been firmly attached to the enterprise, or if when some of them leave their places can immediately be taken by others, it is a comparatively easy matter to supply the rest of the crew, which in reality are nothing but common laborers, whose occupation—the turning of the windlass to haul in the nets, the killing, cleaning, and salting of the herrings—is a useful one, but does not require much thought. These assistants and laborers are during winter employed chopping wood and doing small jobs which do not pay as well as the herring-fisheries. The only trouble about these men has been that the Dutch (up to the present time without result) have endeavored to entice them by promising fixed wages instead of a percentage, and by representing that the Emden enterprise would soon come to an end owing to lack of funds. It therefore seems all the more important for the association to secure a good stock of experienced men, especially captains and mates, and make them firmly attached to the enterprise. Men of nautical experience do not dread the dangers of the sea in winter, but they want to have steady occupation and pay. They look down upon the summer fisheries, and consider themselves and the "loggers" too good for these. But from August on there are frequent storms, which require nautical knowledge and experience in managing the sails and the nets. To a genuine sea-faring man occupation on shore is only a very poor substitute for his favorite employment. And as they, just like other people, are subject to the force of habit, it would

* The coast of East Friesland was, as is well known, visited by a storm-flood toward the end of January, 1876, the most violent during this century. A similar flood occurred in December, 1863, and experience has demonstrated that winters like that of 1876–'77 occur once in 12–15 years.

be, so to speak, against their nature to show all their talents and virtues immediately after going to sea, after having either loafed round on shore for months, or been engaged in some occupation utterly distasteful to them.

These talents and virtues are still more lulled to sleep by the beginning of the herring-fisheries during the calm summer months; and this circumstance has its own peculiar dangers. The majority of the crew is composed of men who have spent most of their time on shore, and who have but little experience in nautical affairs. They do not readily understand the object of the captain's orders and arrangements, and, following their instinct of tardiness, they always advocate a policy of procrastination and waiting. If the captain allows himself to be influenced by their talk, which will often be the case if those of the crew who possess some nautical experience do not immediately take his part, something is sure to go wrong. But if the men of nautical experience have become thoroughly identified with the vessel, they will take a firm stand and there will be better order on board from the first day of the voyage.

All these circumstances determined the managers of the enterprise to begin the first winter fisheries with a very full crew. In England four to five adults and one boy are considered a sufficient crew; but our managers selected one boy, three "logger" captains, and three mates, to be instructed in trawl-fishing by an English master. The command was left in the hands of the captain of the Oldenburg; the two other captains became first and second mates. In order to avoid jealousy, they all received the same, viz, captain's wages; the captain of the Oldenburg receiving a trifle more for a few necessary expenses connected with his office. The three mates were appointed as sailors. The wages were fixed by giving the men a share of the gross receipts, but a minimum monthly sum was guaranteed to them; this sum will have to be paid at any rate during the first years. It was of course understood that the men were to receive their board. Although the new enterprise exposes the men to many difficulties and hardships, it soon found great favor among them, and when, during the following winter, two more "loggers" were fitted out, the places on these were in great demand, which is not at all astonishing if we hear what those seven men on the first "logger" earned besides free board. They earned the following:

	Winter fisheries.	Herring-fisheries.	Total.
John Janssen, as captain	$117 16	*$157 60	$274 76
Aric Bass, as first mate	111 00	*159 48	270 48
J. Gerhard Janssen, as second mate	111 00	*225 46	336 46
J. de Geus, as sailor	74 00	†91 73	165 73
F. de Vries, as sailor	74 00	†130 93	204 93
John Visser, as sailor	74 00	†99 39	173 39
H. Putting, as boy	44 40	‡38 58	82 98

*As captain. †As mate. ‡As boy.

Two of the men who had the good luck in the herring-fisheries to exceed the limits of the minimum share made a very good living, while the others might console themselves over the moderate result of the herring-fisheries—obtained by their vessels—with the thought that their total earnings amounted to a sum which they could only have gained from the herring-fisheries under very favorable circumstances. The winter fisheries thus remunerated them in advance for the unfavorable results of the later herring-fisheries.

As soon as the combined fisheries yield steady results the managers will be able to pay such good annual wages that the best men will not think of leaving them. During the first year only five months' wages were paid; during the following year—and so on—one month more. By adding, therefore, about 20 per cent. to the above figures we will get the next minimum earnings, and by adding 50 per cent. more we would get near the maximum which can be attained. The wages should, therefore, in the future, if everything is managed properly, be as follows: lows:

	Herringfisheries.	Winter fisheries.	Total.
Captain....	$200 00 to 300 00	$137 05 to 200 00	$337 05 to 500 00
Mate.......	125 00 to 187 05	112 05 to 150 00	237 05 to 337 05
Sailor......	100 00 to 150 00	87 05 to 125 00	187 05 to 275 00

and in the same proportion for the rest of the men.

The uninterrupted service of the herring-fishery association has moreover another advantage, which the service on sailing vessels offers but rarely: the men can twice a year visit their families for several weeks, and besides this several times for a few days. It is but natural that under these circumstances the service meets with greater favor from year to year.

The Oldenburg has brought upwards of 50,000 pounds of fish into the market from February to May, 1876. If the fisheries are established on a firm basis, and commence in the beginning of December, every vessel could easily catch double this quantity of fish. Eleven "loggers" would therefore catch about one-half million kilograms of fish per year.

It would be very desirable, and would contribute greatly to make the use of salt-water fish as an article of food more common in Germany, and would make them cheaper, too, if the association would as soon as possible bring their fish into the German markets. So far, however, the Hull, Grimsby, Yarmouth, and Lowestoft markets have offered greater advantages than the German ones. The above-mentioned ports supply the city of London, which is said to consume as much fish, oysters, crabs, &c., as meat, on a large scale; the transportation by rail being organized in the most perfect manner. In Germany, the salt-water fisheries are looked down upon by the railroad companies; in England and Scotland, the very reverse is the case.

In most of the English ports there are special docks in which hundreds of fishing-vessels land early in the morning. Close to the water, open halls have been built on the quays which are used for sorting, cleaning,

packing, and the public sale of fish. Recently a second story has been added, in which the ship-owners, merchants, agents, and commissioners have their offices, for which the railroad company get a good rent, fully paying the interest of the money invested in these buildings. Immediately on the other side of these halls is the railroad track. Near the depot there are ice-houses—the ice mostly comes in blocks from Norway, and is brought to the halls in sacks, where it is ground in small mills turned by hand—smoke-houses, and other buildings owing their existence to the fisheries. Not far from the depot there are dry-docks in which vessels can easily be repaired or cleaned in a few days. "Time is money," is the prevailing thought which prompted the erection of all these buildings which have sprung up like mushrooms. Within the space of two to three hours all the fish have been sold for cash at the public sales which any one can hold. The cleaning, packing, &c., all combine to produce the liveliest activity. One train after the other rolls up to the halls; open cars carry the four-wheeled fish-wagons, which have three to four water-tight compartments; at 4 p. m. all business is finished; the business man can return to town and play the "gentleman."

At the fixed time the fish-trains start, so as to reach their destination early the next morning. Immediately on their arrival one car after the other moves up to a ramp; the shaft of the fish-wagon, which has been lying under it, is placed in position, the horses, of which every large railroad company keeps some thousands, and which stand ready, are hitched to the wagon, and the railroad company does not consider its duties fulfilled until the wagon halts before the door of the fishmonger.

In stores which combine practical arrangements and cleanliness the fish are exposed for sale in the most tempting manner, lying on slightly inclined marble counters with small grooves to gather the moisture which collects by degrees, and kept cool by large pieces of ice. A few hours again suffice to sell all the fish. The great variety in the English methods of preparing fish undoubtedly contributes its share toward this rapid sale, and even a little *hautgout* is masked by a sharp sauce. Englishmen rely on the conscientiousness of the agent of the board of health in the matter of excluding spoiled fish from the market, and it is well known that, especially during the summer months, large quantities of fish are inexorably condemned.

In England ice is used very extensively to keep fish from spoiling, while in Germany there is a good deal of prejudice against employing ice. Who does not recollect the violent outcry of short-sighted Hamburg and Bremen dealers against the so-called "joint-stock company fish," *i. e.*, fish on ice, declaring that it was every way inferior to the "fresh," *i. e.*, half-dead fish, the worthy companion of the Scotch herring? These men, by their violent denunciations, actually succeeded in forcing some associations, which had been dealing in fish on ice, to close their stores. Fish-eaters should not allow themselves to be deceived in this manner, but should rather try it once more, for the dif-

ference of flavor is only imaginary; haddock on ice is at least as wholesome and nutritive as so-called "fresh" haddock. Even in the markets of sea-ports you do not find any really "fresh" or "live" haddock, as it dies very soon when taken out of its true element, the briny water of the ocean. The haddock does not come near the German coast till late in spring, when the lenten season is over, but the "logger" could easily fish them in those places where they come earlier in the season. The Oldenburg generally got $2\frac{1}{2}$ cents per pound in the Hull market, while, so far German dealers have not offered more than $1\frac{3}{4}$ cents per pound, on condition, it is true, that they would pay cash on the arrival of the vessel and engage to take the whole cargo. As matters stand at present the question of making this fish, which occurs in great numbers, really profitable remains altogether in *statu quo.* If the German press would take an interest in the salt-water fisheries, which, unfortunately, it does not, many of the existing prejudices would soon be rooted out. All the existing difficulties could be met if there were sufficient funds. It would require a strong organization to obtain the same net prices as in England; it would require ice-houses and other buildings which scarcely exist in most of the German ports, not even in Emden. The railroads would also have to take a greater interest in the matter.

The Hansa (German paper) recently explained a concession which it had made to public opinion in the following manner: "After the fisheries in the German Ocean had dwindled down to a very small trade, chiefly owing to the unfavorable railroad connections, the railroad companies have lowered their freight rates, which one and a half year ago had been declared unnecessary, because it is said the fishing trade did not patronize the railroads." In the interest of the existing ocean-fisheries this measure is to be hailed with joy, as it publicly testifies to a more favorable view of the whole question taken by the railroad companies. It can scarcely be doubted that the railroads will find it in their own interest to grant still more favorable conditions as soon as they can be assured that considerable quantities of fish will be shipped.

When the Emden joint-stock herring-fishery association was started the great capitalists assumed a hostile position toward the enterprise. The Emden people were not inclined either to promise very large dividends; nor would it have been possible to obtain large sums of money on such hard conditions as were customary at that time; consequently it was determined to raise the money privately among friends and well-wishers who were well acquainted with the final aim which the association had in view. The managers of course expected to meet with difficulties, but they hoped to conquer these by increased activity. But instead of this they met with reverses in 1875, and since then not much progress has been made. All sources of self-help have unfortunately been exhausted, and it cost a great deal of trouble to raise the necessary means for carrying on the herring-fisheries during this summer.

The chief creditor of the association was induced to wait for the pay-

ment of his money, which had been borrowed at 6 per cent. interest, till the end of this year's herring-fishing season, and even advanced some more money; and the minister of agriculture gave from his limited contingent fund $1,500 as a present, and $1,500 more to be repaid whenever it would be convenient. But even with such help the enterprise cannot be established on a firm basis, and when the herring-fisheries have come to a close this season the association will have to decide the question, whether besides the three "loggers," which according to agreement are to be left rent-free to private individuals during the winter 1877–'78, they will be able to fit out some more "loggers" in order to carry on the winter fisheries for the association. The management of the trawl-net can easily be learned, if only half the crew has some experience. If, therefore, the association were to fit out three more "loggers" for the winter fisheries 1877–78, it will be possible when the contracts with crews are made for the next herring season to promise steady employment from that time on to the whole stock of the crews possessing nautical experience. The future of the enterprise, which at present can neither die nor live, would then be secured if there were sufficient funds to make use of all the advantages.

It is well known that the association has laid a petition before the "house of delegates" (lower house of the Prussian parliament) to let them have a loan from the national treasury at a low rate of interest; and the house has by a large majority recommended this measure to the government. If this aid is granted, the enterprise, which so far stands alone in Germany, will be enabled to fulfill its economical mission also in the future. It is true that other enterprises which receive aid from the state, such as railroads, have similar aims, but then many of these pursue a competitive aim within the national boundaries, which is not the case with the herring-fisheries. For similar enterprises which might spring up will be able to start at a great advantage by not having to learn at a great expense all that which the Emden association had to learn. There can be no question of unlucky results, as every lender remains master over his future resolutions. The whole enterprise, moreover, means nothing less than a national competition with Holland and Great Britain, where capitalists are satisfied with lower rates of interest than in Germany. After it has within its present limits become more consolidated, it will soon be able to command private capital for the purpose of extending its sphere of capacity. It would have to be deeply deplored, if all the experience bought with so much money should be lost to the nation; for if the association were to declare itself bankrupt, their vessels would be sold in Holland, where they would fetch the highest price, and the buildings would have to be sold at a great loss, to be used for other purposes. Another generation would pass away before any one would again think of confronting the difficulties inevitably connected with the beginning of high-sea fisheries. This would have to be deplored all the more, as the managers

may have committed mistakes but have never been guilty of any wrong or dishonest act. The whole cost of administration has been so cheap, that every joint-stock company should take an example from it. The members of the board of directors receive no percentage. The report for 1876 will show, in conclusion, that the property, according to its book-value, represents about 75 per cent. of the whole joint-stock capital. But the actual value is even higher; thus the real estate is only reckoned at $19,062.50, and the eleven vessels at $58,762.50, while the latter have been issued at a value of $70,975. With the exception of lack of funds, the condition of the association is a healthy one throughout. The city of Emden and many patriotic Germans throughout the empire hope that his excellency the minister, Dr. Friedenthal, who looks on the enterprise with favor and who is fully competent to understand all its needs, will be able to find a way by which its future existence and prosperity can be secured.

APPENDIX B.

THE PROPAGATION OF FOOD-FISHES.

X.—THE BEST FOOD FOR YOUNG SALMONOIDS AND FOR LARGER SALMONOIDS IN PONDS.

[From circular No. 4 of the German Fishery Association, Berlin, May 28, 1877.] *

At the meeting of German pisciculturists held at Berlin, May 1 and 2, 1877, discussion on the above question was opened by Mr. Schuster, of Freiburg. He said that this question was one of great importance in more than one respect, and that he was desirous of obtaining information from competent persons. As regards the very young fish, some might say that it would be best not to feed them at all, but put them in ponds before they seek their food, and while they still have a small remnant of the umbilical bag. But this is not always advisable, for if the snow melts very suddenly the young fish are easily destroyed by the high water. Mr. Schuster, in conclusion, remarked that a Swiss had offered him a recipe for procuring a never-failing supply of suitable food, but he demanded no less than $4,000 for divulging the secret.

Mr. Haack, of Hüningen, made a long speech on this question, which he considered the most important question in pisciculture. He recommended the following food for young salmonoids: The larvæ of gnats, the small larvæ *Daphnia*, *Cyclops*, &c., which are skimmed off stagnant water (ditches, pools, &c.) with a fine muslin skimmer. Two children do this early in the morning and in the afternoon, and he says he in this way gets enough food every day to feed 20,000–30,000, and even 50,000 young fish. This is the most natural food for them, but not the cheapest. Mr. Haack said he did not like to feed the fish inside the building for any length of time, for even if the fish grow till they lose their umbilical bag they are easily affected by the *Achlya prolifera* or fungus. The larger fish are fed on the larvæ of the "Kriebelmücke," a sort of gnat which are found even in the coldest trout-brooks. The females of this species of gnat generally deposit their eggs on floating grass.

Ground meat ("Fleischmehl," meat-flour) and ground Norwegian fish ("Fischmehl," fish-flour) seem to deserve special attention. According to information received from Mr. Kuffer, three to four parts ground meat are mixed with one part common flour. The ground meat is boiled a little in hot water and then the flour is stirred in. He had not yet tried

* Which is the best food: (a) for young salmonoids and (b) for larger salmonoids in ponds where no food-fish can be obtained?

Welches Futter ist das beste: (a) für Salmonidenbrut, und (b) für grössere Salmoniden in Teichen, wenn keine Futterfische zu erhalten sind? Aus circular No. 4 des Deutschen Fischerei-Vereins, Berlin, den 28 Mai, 1877. Translated by H. Jacobson.

this food for small trout, and for small troughs it could not be recommended. Some method would have to be found by which this food could be put up in a shape that would be more acceptable to the fish. Further experiments should at any rate be made with it, especially with a view of feeding trout in ponds.

During the first years Mr. Haack had frequently fed the larger fish with horse flesh, and this kind of food deserves some attention. But unfortunately a good deal is required, and one is too much dependent on the dealer, so that frequently, when too much meat is on hand, it becomes necessary to salt it down. The price of this meat was at that time one and a half cents a pound; the fish often preferred the salt meat to the fresh. For the one year old fish it was chopped in a meat-cutter, and for the larger fish it was according to their age cut in small and large cubes. The meat never putrefied in the water, for if the fish are properly fed not a single piece will fall to the bottom. The fish remembered the persons who fed them and came near the shore as soon as they noticed them. On some holiday, however, when many people came to Hüningen to visit the fish-breeding establishment, the attendants during his absence fed the fish too much (for the sake of the gratuity which they received from the visitors), a great quantity of meat remained lying at the bottom, and by its putrefying, a good many fish were lost. Otherwise the results at that time were very favorable, and a thirty months old trout had simply by artificial feeding reached a weight of three pounds. But one day the trout in all the ponds got sick very suddenly, so that three to four thousand pounds were lost, and this phenomenon cannot be explained in any other way but by supposing that the fish had been fed on diseased meat. The greatest care must therefore be exercised, and nothing but sound meat should be used.

Mr. von dem Borne asked whether Mr. Haack had ever fed the fish with maggots. He had heard it recommended to lay meat in boxes placed over the water, and having a perforated bottom so that the maggots could fall into the water. Other people again advised to gather the spawn of frogs, and raise young frogs for food.

Mr. Haack replied that it was unpleasant and not advisable to feed the fish on maggots, as some of the meat was thus lost to them. Frogs could not very well be raised artificially; it was better to gather them, but care should be taken not to transfer them from warm water into cold trout-ponds. He would recommend frogs as food for somewhat larger fish; the only drawback was that frogs could not be procured anywhere and at any season, particularly not in South Germany, where there was also a lack of larvæ, which are more frequent in North Germany where there are more stagnant waters.

Mr. Kuffer said that he had fed small trout, after they had lost their umbilical bag, with perch-spawn, which he could easily procure, as well as with ground liver.

Mr. Brüssow recommended sheep's liver ground through a fine sieve and mixed with water.

Mr. Schuster remarked that, with the exception of the ground meat, he had tried all the articles of food which had been mentioned, and many more besides such as dried ants' eggs ground fine, worms, &c.; but nothing seemed to give entire satisfaction. As a very suitable food he would recommend calf or sheep's brain ground through a fine-wire sieve. It swims on the water for a long time and looks as if it was alive. It was moreover particularly good for the fish on account of the great quantity of phosphoric acid which it contained. For large fish this kind of food, however, would be too expensive; these he fed with lungs, milt, salt meat, salt fish, &c., also occasionally with boiled meat. With regard to salting, Mr. Schuster has had the same experience as Mr. Haack. The fish like salt meat, as he found out accidentally when he received some fish for food which were almost spoiled so that they had to be salted. Afterward they were soaked in water, but did not lose their salty flavor entirely; the fish, however, ate them readily.

Mr. von dem Borne feeds lungs slightly boiled in salt water.

On motion of Mr. Eckardt, it was unanimously resolved to hold annual meetings of pisciculturists, since this present meeting had been accompanied by such satisfactory results, and the wish was expressed that these meetings should not always be held in Berlin.

Mr. Brüssow reported on his *artificial raising of crawfish.* He uses a basin having wooden walls 44 feet long, 20 feet broad, having a depth of water of 4 feet. At the bottom there is on all four sides a layer of bricks, laid flat, and on this there are 45 layers of drain-pipes cut in halves right across. One hole of these pipes is closed by the wall of the basin, but the other is open, so that the crawfish can crawl in. This seems to have been a very happy idea, for the pipes are all inhabited, and the crawfish only leave them to get their food or when the water of the basin is let off. The large crawfish were fed with fresh meat, fresh fish, and carrots, and the small ones with carrots cut in cubes.

He commenced his experiments last spring; 1,400 female crawfish with eggs were placed in the basin, and produced about 20,000 young ones. Generally each female produces 70–80 young ones, but these crawfish had suffered a little from the long journey, and were therefore not quite so prolific. In the beginning the young crawfish were about the size of a fly; in July they were placed in another basin, having a water depth of 4 feet and full of fagots and aquatic plants. At the end of October the crawfish were as large as a good-sized Italian bee, and resembled this insect somewhat by the manner in which the back part of the body was marked, only that they had black stripes on a gray background. The water does not flow into this basin very freely, so that it is only renewed every three days.

Last autumn Mr. Brüssow put 600 male crawfish to the females, and these must have copulated with them, as the females have now eggs

under their tails. The young crawfish which he had last year raised in his basin were in great demand, and fishermen paid $5 a thousand. He was doubtful whether it would be profitable to raise crawfish in ponds till they had reached their full size, but he recommended to place the young ones in open lakes.

Mr. von dem Borne remarked that he kept crawfish in a basin whose walls were cemented. It is 12 feet long and 1 foot deep. He had observed the male crawfish copulate with the female, and had then seen the female lay eggs. Some females had, from some unknown cause, not laid any eggs.

The great crawfish establishment of Mr. Micha, in Berlin, was mentioned, and Mr. Kuffer remarked that he also kept crawfish all winter through. He buys them in September and October, and feeds them with the entrails of fish, which the crawfish like. In the beginning they ate a great deal and finally got quite fat.

XI.—REPORT OF OPERATIONS AT THE SALMON-HATCHING STATION ON THE CLACKAMAS RIVER, OREGON, IN 1877.

BY LIVINGSTON STONE.

On the 15th of May, 1877, I received a telegram from Prof. Spencer F. Baird, United States Commissioner of Fish and Fisheries, requesting me to proceed with all possible dispatch to the Columbia River to report to the Washington and Oregon Fish Propagating Company* for the purpose of conducting operations, under their auspices, in hatching salmon on that river or its tributaries. I had had during the previous winter some correspondence with Mr. J. W. Cook, of the Oregon Packing Company, at Clifton, in regard to going to Oregon with this object in view, but owing to a want of sufficient local interest in the subject the matter was dropped until the very marked falling off of the spring catch of Columbia River salmon called the attention of the cannery men to it again and led to the formation of the above-mentioned company and the dispatch just referred to.

In pursuance of Professor Baird's instructions I left the East as soon as practicable and arrived at Portland, Oreg., on the 11th of June, having spent a short time *en route* at the McCloud River, California, a notice of which will be found in my report of operations at that point. On the 13th of June I met the directors of the Washington and Oregon

---

**Articles of incorporation and by-laws of the Oregon and Washington Fish Propagating Company. Principal office at Portland, Oreg.* Incorporated April, 1877.

Directors.—John Adair, jr., J. W. Cook, J. G. Megler, J. West, C. H. Lewis.

Officers.—John Adair, jr., president; Joseph G. Megler, secretary; Henry Failing, treasurer.

ARTICLES OF INCORPORATION.

Know all men by these presents that we, C. Leinenweber, James W. Cook, John West, Joseph G. Megler, John Adair, jr., and J. P. Bannan, citizens of the State of Oregon, do by these presents associate ourselves together as a corporation under and by virtue of the general incorporation laws of the State of Oregon, and for such purpose we do jointly and severally hereby agree to and with each other to the following articles:

ARTICLE 1. The name assumed by this corporation and by which it shall be known is the Oregon and Washington Fish Propagating Company.

ARTICLE 2. The duration of this corporation shall be unlimited.

ARTICLE 3. The enterprise, business, pursuit and occupation in which this corporation proposes to engage, is to propagate, breed, and multiply salmon and other species of fish in the waters of the Columbia River and its tributaries, and to do a general fish-culture business; to purchase, own, hold, occupy, and dispose of real estate, and

Fish Propagating Company at Astoria, and there received instructions to proceed up the Columbia River and find, if possible, a suitable place for erecting a large and permanent salmon-hatching station.

I had, two years ago, gone to the Columbia in compliance with instructions from Professor Baird for the same purpose, and had at that time reported to him in favor of the Clackamas River, which I then made up my mind was the best location in the Columbia River Valley for a hatching establishment for salmon.

On expressing this opinion on my second visit to the Washington and Oregon Fish Propagating Company it was met by the statement that the salmon of the Clackamas were not the right kind, being Steel-heads (*Salmo Gairdneri ?*) instead of Chenook salmon (*Salmo Quinnat*), which is the kind used for canning. This proved ultimately to be a mistake, but at the time it appeared a sufficient reason for abandoning the Clackamas River, and I spent the next five weeks, from June 13 to July 16, in examining different points on the tributaries of the Columbia. The result was that almost every tributary between the sea and Walla Walla River was investigated and all with unfavorable results. Some, like the Des Chutes, had plenty of salmon in them, but were unmanageable. Others, like the Umatilla, were easily controlled, but deficient in salmon.

---

erect such necessary buildings and improvements thereon, and to purchase, erect, and maintain all necessary furniture, &c., for hatching salmon and other fish.

ARTICLE 4. The principal office and place of business of this corporation shall be at the city of Portland, in the county of Multnomah, and State of Oregon.

ARTICLE 5. The amount of the capital stock of this corporation shall be the sum of $30,000, United States gold coin.

ARTICLE 6. The amount of each share of such capital stock shall be the sum of $50, United States gold coin.

In witness whereof we have hereunto set our hands and seals in triplicate this 6th day of April, 1877.

C. LEINENWEBER. [SEAL.]
J. W. COOK. [SEAL.]
JOHN WEST. [SEAL.]
JOSEPH G. MEGLER. [SEAL.]
JOHN ADAIR, JR. [SEAL.]
J. P. BANNAN. [SEAL.]

In presence of—
C. A. DOLPH.
JOSEPH SIMON.

STATE OF OREGON,
Multnomah County, ss:

This certifies that on this 6th day of April, 1877, before me, the undersigned, a notary public in and for said county and State, personally appeared C. Leinenweber, James W. Cook, John West, Joseph G. Megler, John Adair, jr., and J. P. Bannan, to me personally known to be the identical persons described in and who executed the foregoing articles of incorporation, and acknowledged to me that they executed the same.

Witness my hand and official seal the date above written.

JOSEPH SIMON,
Notary Public, Oregon.

Others still, that were both manageable and abounded in salmon, were too distant or inaccessible to be utilized. So all the spawning-streams up to the Walla Walla River, one after another, had to be given up in consequence of some fatal objection which made them unavailable.

Owing to the Indian troubles, which were then very serious, it was unsafe, and in fact wholly out of the question, to go to the Clearwater or Salmon River, or to the Yakima or any of the tributaries of the Upper Columbia.

Although the prospect was so discouraging, I nevertheless left Mr. Hubbard at Umatilla to put a rack across the Umatilla River to obstruct the ascent of the salmon in case they came up; and later in the season, hearing that salmon were expected in large quantities in the river, I sent Mr. Richard Hubbard to the Umatilla on the 19th of September to make an examination of the river. He found no salmon there, and having reported unfavorably on the place it was given up.

On the 16th of July, while the proposition was being discussed by the directors of the Oregon and Washington Fish Propagating Company of postponing all operations till another year, I suggested to them to make an examination of the Clackamas River before abandoning the enterprise entirely for the year.

The result was that the Clackamas was examined and found suitable for the purpose in every respect, and on the 18th of July I received by telegraph the following authorization to proceed with operations on the Clackamas River:

"ASTORIA, OREG., *July* 16, 1877.

"TO LIVINGSTON STONE,

" *United States Fish Commission:*

"You are hereby authorized to take such action and make such arrangements as you think necessary and expedient in the matter of salmon hatching.

"JOHN ADAIR, JR.,

" *President Oregon and Washington Fish Propagating Company.*"

Having examined the river, first by traveling along the bank for 25 miles, and afterward going up the stream 20 miles in an Indian canoe, I decided upon locating the hatching-works on the south bank of the Clackamas, just above the mouth of Clear Creek.

As soon as this decision was made, I telegraphed to Mr. Waldo Hubbard, at Umatilla, to come to the Clackamas River, and having communicated my plans to him for a hatching-house, a dwelling-house, water-supply, &c., returned to the McCloud River reservation in California. I remained there until the operations of the United States Fish Commission at that point had been placed in good running order, when I returned to the Clackamas River. On arriving at the hatching-station, on the 10th of August, I found that the work had been pushed with vigor by Mr. Hubbard, and had made very satisfactory progress. The mess-house was finished, the hatching-house was nearly completed,

a rack had been built across the river, and the dwelling-house had been begun.

A large amount of work had been done also toward obtaining a water supply by placing a dam across Clear Creek, 100 rods from its mouth. The original intention was to lay the foundation of the dam on bed-rock, and then to build up to the height required to convey water to the hatching-troughs.

It soon became evident, however, that the bed-rock lay deeper than was supposed. Two gangs of twenty men each—a day gang and a night gang—were put on the work, and a great effort was made to reach the bed-rock, but without success, and on the 18th of August it was found necessary to abandon the place altogether and to resort to some other method of raising the water.

On the 29th of August, Mr. Adair, president, Mr. J. W. Cook, vice-president, and Mr. Megler, secretary of the Oregon and Washington Fish Propagating Company, visited the place, and authorized the building of a dam by contract and the purchase of steam-pumps to furnish a reserve supply of water in case of emergency. It was ultimately found, however, that these could not be furnished for less than $5,275, and such an expenditure not seeming to be warranted by the circumstances, I was then authorized to raise the water by a current-wheel. Work was immediately begun on the wheel, which was finished on the 22d of September. It was several days before the elevator and shore attachment were completed, so that it was not till the 25th of September that the wheel-work was complete, and a permanent supply of water furnished for the hatching-house. In the mean time, work on the other departments had been prosecuted with energy; the hatching-house was fitted up with eight lines of troughs and wire baskets, each line having a hatching capacity of a million eggs. A substantial flume had been built from the wheel to the hatching-house, and everything put in readiness for the transfer of the salmon-eggs from their temporary position in the river to the regular hatching-trays.

We will now go back to the middle of August, in order to get a thorough comprehension of the progress of the season in regard to the salmon and salmon eggs, which, of course, are the central objects of the whole work. Up to that time no salmon of any consequence had made their appearance in the river in the vicinity of the hatching-works. Occasionally a straggler had been seen below the rack, and that was all; but after this time more and more appeared every day, though still in very small numbers. There were, nevertheless, enough to show that the movement of the salmon which immediately precedes the spawning-season had begun. Accordingly, on the 1st of September we made a haul with the seine a short distance below the rack. A few salmon were caught, but they appeared to lack a week or two yet of being ripe. The salmon caught at intervals during the next ten days presented the same appearance, though we, of course, naturally enough

expected that the later-caught ones would be riper. This led to quite an important discovery, viz, that the unripe salmon coming up the river to spawn proceeded directly up as far as the rack, and then, not finding a passage through or a suitable place where they were, fell back to a spawning-ground that lay about 80 rods below. This accounted for our always catching green or unripe salmon at the rack. Upon this discovery being made we abandoned fishing at the rack, and began drawing the seine at the spawning-ground just mentioned, where we found ripe salmon the first time we fished, which was on the 12th of September.

In the mean time I had begun catching salmon and taking eggs a few miles up the river. A double purpose was accomplished by this step. In the first place, persons acquainted with the river assured me that a considerable number of eggs could be procured there from the salmon, which were then spawning; and in the second place, and what was a far weightier consideration, it had become absolutely necessary to get rid of some Indians who were trap-fishing for salmon a few miles below us. As long as their trap remained in the river below, it was useless, of course, to expect salmon to reach our seining-grounds at the fishery. I accordingly arranged with the Indians through Mr. Louis Barin, mayor of Oregon City, of whose invaluable assistance more will be said hereafter, to take up their trap below us and place it at a spawning-ground six miles above the fishery, and for a suitable compensation to catch salmon there for us to spawn. This served the double purpose of getting additional eggs for the hatching-house, and, what was of the utmost importance, of ridding the river below us of the trap-fishing, which was proving fatal to our salmon-hatching operations.

The Indians were a poor lot, and did almost nothing, but between them and the regular seining at the fishery we caught enough salmon by the 15th of September to yield nearly 200,000 eggs, which were placed in river-boxes under a temporary brush covering near the shore.

On the night of this day, which will be always known at the Clackamas fishery as *Black Friday*, and which well deserves that name, the river rose very suddenly and poured down such a rapid and resistless torrent that it swept away everything we had in the river, including the rack across the Clackamas, the Indian trap above, the corral for confining the parent salmon, and the 200,000 salmon eggs which had been collected in the river-boxes. The mischief caused by this rise in the river might have been averted had we been able to procure definite information regarding the time when the salmon spawned and the character of the September rise in the Clackamas; but information in a new country like this, where no careful observations have been made and no record kept, it was impossible to get. Hence the accident. Enough was learned about the river this year, however, to prevent a similar occurrence in future. A day of gloom and depression succeeded this disaster. With the rack and trap gone, the season's harvest and

the reserve of spawning salmon lost, and no time left to retrieve, things had a very gloomy outlook.

Several other circumstances added to the general discomfiture. It was reported that the mouth of the Clackamas was entirely closed by a trap which had been put in to catch the fall salmon ("Silversides"). The roads had been made so bad by the heavy rains that every one of the lumber-teams had broken down, and an entire embargo from this cause placed on our lumber supply. Lumber was still wanting to finish the flume and boats, without which, of course, the hatching-house was useless, and that portion of the flume which was completed was so soaked by the incessant rains that it could not be covered with the indispensable coating of asphaltum. The prospect was disheartening enough, but before night I resolved to redouble my exertions to secure spawning salmon and to push the general work forward regardless of discouragements.

I sent to the United States salmon-breeding station in California for eggs enough to replace those that were lost. I hunted up the corral containing the reserve of spawners and found it on a bar a mile and a half below, with the fish in it all alive and well. I detailed seven men to run the seine, with instructions to spare no pains, day or night, to secure all the spawning salmon possible. Agreeably to the proverb "*Fortuna juvat fortes*," circumstances seemed to favor our unequal struggle with misfortunes. My men, when they ascertained my determination to push forward, took hold, much to their credit, with an enthusiasm which, I believe, was entirely independent of their compensation. Before night the rains ceased, and the sun came out for the first time in fifteen days. The roads soon improved; the lumber-teams started up again; the flume became dry enough for the asphaltum; the spawning salmon seemed to remain about where they were, though they were now free to ascend the river. In two days we began to take more eggs, and in less than a week affairs at the fishery wore an entirely different aspect, and there seemed to be a chance left yet of hatching some salmon on the Clackamas.

The general work being now well under way again, my special anxiety was concerning the wheel and the elevator for raising the water, which were being built on flat-boats opposite the upper end of the flume. The wheel furnished the power for raising the water, but being only 12 feet in diameter could not raise the water to the height of the flume on shore, which was 26 feet above the low-water level of the river. An elevator consequently had to be attached to the wheel in order to lift the water to the flume. This elevator had at first nineteen buckets, holding five gallons each, and was geared on to the wheel by an 8-inch rubber belt. On the 23d of September the work was sufficiently advanced to start the wheel, which was done; but before a single revolution was made, the belt flew off the drum, showing that although the wheel had power enough to lift the water the belt had not sufficient

capacity to match. Some of the buckets were then knocked off the elevator and the wheel started again. This time it revolved successfully and was found to be lifting to the flume 8,000 gallons of water an hour, which was quite sufficient for this season's operations, and so another anxiety dropped off, and another forward step was accomplished. Before trusting the eggs to the water-supply now furnished by the wheel, I had the lifting apparatus watched two days and nights to make sure that the supply would be continuous. All doubts were removed at the end of forty-eight hours, and at noon on the 25th day of September, 1877, the water was turned regularly through the hatching-house and the salmon eggs brought up from the temporary hatching-boxes in the river and placed in the hatching-troughs. This inaugurated the regular work of the Columbia River salmon-hatching establishment on the Clackamas, which is probably destined to be, for the present at least, the largest in the world, and to exercise a very important influence both on the salmon fisheries of the Columbia and on the world's supply of canned salmon.

Having now succeeded in placing the hatching establishment in successful running order, the next thing was to make it safe. This was a more serious and difficult matter than one would naturally suppose. The Clackamas River, in the dry season, is a pleasant and quiet though somewhat rapid stream, and looking upon it at that season an uninformed person would never suppose it could prove dangerous to such stanch and substantially-built boats as those upon which our water-lifting apparatus rested. But in the wet season the Clackamas becomes a furious and terrible river, bringing down in its current immense trees, root, trunk, and branches, the smallest of which would wrench our boats from their moorings, or, if they remained stationary, would crush them in pieces. Consequently, to make the boats safe became as difficult as it was indispensable. It was accomplished, however, by the joint help of a breakwater and an enormous boom. The breakwater was built of 3 inch plank, resting on heavy timbers, and so placed as to form a convenient and perfectly safe harbor for the boats to retire to when required. The breakwater is nearly 100 feet long and is built up so as to reach above the extreme limits of high water. This protects the boats when moved into the harbor, but of course does not save them from drift-wood when they are stationed in the current. To accomplish this latter result is the object of the boom. This is an immense floating barrier 30 inches square and nearly 100 feet long, weighing over ten tons, made of four single squared timbers firmly bolted together. The upper end is chained to a rock in the river, which forms the outside abutment of the barricade, and the lower end extends just outside the boats, forming a complete safeguard against drift-wood coming down with the current. As above mentioned, the drift-wood is very formidable when the river is high, entire trees, roots and all, with trunks not less than 6 or 8 feet in diameter, not being an unusual sight in the river after heavy

rains. A boom twice as strong as ours would, if placed at right angles with the current, be broken like a pipe-stem by this drift when the river is high and rapid; but to obviate this our boom is kept, by spars extending from the shore, at an angle of not over 20° with the current, in consequence of which, whatever drift strikes it simply slides by outside of the boats and goes on down the river without doing any harm.

The water-supply for the hatching-house having been made secure by these expedients, it only remained to finish the dwelling-house and stable connected with the fishery, and the season's work was done, with the exception of placing the young salmon in the river.

When I left Oregon, the latter part of November, about half of the fish had been deposited, and the balance, in charge of Mr. Waldo F. Hubbard, were likely to be ready some time in December. The total number of young salmon, including both those placed in the river and those still remaining in the hatching-house, was nearly a million.

Considering the late day at which the undertaking was commenced, and the great and numberless difficulties which attended it from the beginning, it seems to be doing as well as could be expected to even place the establishment the first year in successful working order; and to actually succeed in hatching and turning out nearly a million salmon is, I confess, more than I thought it possible to do this year. Indeed, it was nearly all that it was possible to do. There were over a thousand drift-nets in the Columbia, each 1,200 feet long, running all summer; there were drift-nets and two traps on the Clackamas, and in September a trap reaching nearly across the mouth of the same river, and how could we expect to get many parent salmon to take eggs from at the terminus of a gauntlet like that? The fact was that nearly every salmon that entered the mouth of the Columbia was trapped, netted, seined, speared, or otherwise destroyed before it reached our fishery.

If every salmon which reached the hatching-station after the river was low enough to permit fishing had been caught and spawned, the yield of eggs would not have been very great. This is owing not to the natural scarcity of salmon in the Clackamas, but to the excessive fishing in the waters below, especially at the canneries on the Columbia. This leads me to say that the drift-net and trap-fishing at the canneries of the Columbia are at present pushed to such an extreme degree that unless some restriction is imposed, even artificial hatching cannot be carried on at any point on the Columbia or its tributaries to a sufficient extent to replace the vast number of fish destroyed.

The Clackamas River is undoubtedly the best location there is for hatching the Columbia River salmon in large quantities, and we have just seen how meager the results must be, even there, without some restriction on the fishing below. Without such restriction the Columbia River salmon is doomed, and his days will soon be numbered. But with suitable protection, and with the assistance of the Clackamas

hatching station, the Columbia River salmon fishing has yet a great career before it.

The Clackamas River is one of the great natural spawning grounds of the Chenook salmon (*Salmo quinnat*). Probably no tributary of the Columbia has abounded so profusely with salmon in past years as this river. A high natural fall on the Willamette at Oregon City, just above the mouth of the Clackamas, forces all the salmon of the Willamette up the Clackamas, and vast hordes of them have consequently been in the habit of crowding into that river to spawn. The only thing needed now to make the salmon fishing of the Columbia equal to the best days of its past history is to so protect the salmon that a small percentage of them can ascend the Clackamas. Only a very small percentage will be enough. One-half the salmon that are canned on the Columbia in a single day, if we had them at the hatching station, would give us eggs enough to hatch 50,000,000 young salmon. It is obvious, therefore, that a very moderate restriction of the fishing will answer the purpose. I am happy to say that steps have already been taken toward furnishing such protection, and the Washington Territory legislature, with that object in view, passed a bill last summer, the text of which is given below, and which appears to be entirely satisfactory.

The following is a full copy of the bill, which is entitled "An act regulating salmon fisheries the waters of the Columbia River":

"SECTION 1. *Be it enacted, &c.*, That it shall not be lawful to take or fish for salmon in the Columbia River or its tributaries by any means whatever, in any year hereafter, during the months of March, April, August, and September, nor at the weekly closetimes in the months of May, June, and July, that is to say, between the hours of six o'clock in the afternoon of each and every Saturday, until six o'clock of the afternoon of Sunday following. And any person or persons catching salmon in violation of the provisions of this section, or purchasing salmon so unlawfully caught, shall, upon conviction thereof, be fined in a sum of not less than five hundred dollars nor more than one thousand dollars for the first offense, and for each and every subsequent offense, upon conviction thereof, shall be fined not less than one thousand dollars, to which may be added, at the discretion of the court, imprisonment in the county jail for a term not exceeding one year.

"SEC. 2. It shall not be lawful to fish for salmon in the said Columbia River or its tributaries during the said months of May, June, and July, with gill-nets, the meshes of which are less than four and one-eighth inches square, nor with seines whose meshes are less than three inches square, nor with weir or fish-traps whose slats are less than three and one-half inches apart. Nothing herein contained shall prevent fishing in said river or its tributaries with dip-nets, during the fishing season as established and defined by section one of this act. Every trap or weir shall have, in that part thereof where the fish are usually taken, an opening at least three feet wide, extending from the bottom to the top

of the weir or trap, and the netting, slats, and other material used to close such aperture while fishing shall be taken out, carried upon shore, and there remain during the said months of March, April, August, and September, and the weekly closetime in the months of May, June, and July, as prescribed in section one of this act, to the intent that during said closetime the salmon may have free and unobstructed passage through such weir, trap, or other structure, and no contrivance shall be placed in any part of such structure which shall tend to hinder such fish. In case the inclosure where the fish are taken is furnished with a board floor, an opening extending from the floor to the top of the weir or trap shall be equivalent to extending the said opening from bottom to top. Any person or persons violating the provisions of this section, or encouraging its violation by knowingly purchasing salmon so unlawfully caught, shall be deemed guilty of misdemeanor, and, upon conviction thereof, shall be fined for the first offense not less than five hundred dollars nor more than one thousand dollars, and for each subsequent offense shall on conviction be fined not less than one thousand dollars, to which may be added imprisonment in the county jail for a term not exceeding one year.

"SEC. 3. It shall not be lawful at any time during the year, nor by any means whatsoever, to fish for salmon for the purpose of trade, barter, or sale, on the waters of the Columbia River, west of a line drawn southerly from Scarborough Hill, in Washington Territory, to Tansey Point, in the State of Oregon. And any person or persons bartering, selling, or otherwise disposing for purposes of gain, any salmon so unlawfully caught below the line herein established, or any person or persons knowingly purchasing such salmon so unlawfully caught, or otherwise unlawfully encouraging salmon fishing in such prohibited limits, shall be fined in any sum not less than fifty nor more than one hundred dollars; and justices of the peace shall have jurisdiction to try and determine all complaints for the violation of the provisions of this section.

"SEC. 4. The person or persons making complaint of any violation of the provisions of this act shall, upon the conviction of the offender, be entitled to one-half of the fine recovered; and any prosecuting attorney who shall, upon complaint being made to him of the violation of this act, fail to prosecute the party accused, shall be deemed guilty of a misdemeanor in office, and, upon conviction thereof, be fined in the sum of five hundred dollars for each and every such offense.

"SEC. 5. This act shall not be so construed as to interfere in any way with any establishment or enterprise for the propagation of salmon, whether by the United States Government or any regularly organized company or society for that purpose, located or operated upon said Columbia River or any of its tributaries.

"SEC. 6. It shall be unlawful for the proprietor of any saw-mill on the Columbia River or any of its tributaries, or any employé therein, to cast the sawdust made by such saw-mill, or suffer or permit such sawdust to

be thrown or discharged in any manner into said river or its tributaries. For each and every willful violation of this section, the party guilty of such violation shall be liable to a fine of fifty dollars for each and every such offense, to be recovered before a justice of the peace of the proper county.

"SEC. 7. Any party convicted of any violation of the provisions of this law shall be sentenced to pay the fine and costs adjudged, and in default of paying or securing the payment thereof, he shall be committed to the county jail until such fine or costs shall be paid or secured until he shall have been imprisoned one day for every two dollars of such fine and costs. But execution may at any time issue against the property of the defendant for whatever sum may be due of such fine or costs. Upon payment of such fine and costs, or the balance after deducting the commutation by imprisonment, or securing the same, the party shall be discharged. All fines and penalties collected for violation of this act shall constitute a fund for the maintenance of hatching-houses for the propagation of salmon, and be disbursed in accordance with the provisions of an act entitled 'An act to encourage the establishment of hatching-houses for the propagation of salmon in the waters of the Columbia River.'

"SEC. 8. No section, proviso, or part of this act shall be considered as valid or operative until the legislature of the State of Oregon shall enact a similar section, proviso, or act, in whole or in part; and from and after the passage of such a law by the State of Oregon, such parts hereof as shall be so enacted shall immediately go into full force and effect, and the governor of this Territory is hereby requested to transmit an attested copy of this act to the governor of the State of Oregon, requesting him to submit it to the legislature of that State."

When this legislation has been supplemented by similar action on the part of the Oregon legislature, which will probably be done next fall, operation at the Clackamas River salmon-hatching station will begin on a very large scale, and a few years will see it, without doubt, the largest establishment of its kind in the world, with a yearly yield of young salmon entirely unprecedented.

The extremely intricate but equally interesting subject of the natural history of the Columbia River salmon would find a legitimate place here, but I forbear to venture upon a discussion of it until my observations up to the present time have received further confirmation. I feel quite free to say, however, that I am satisfied that the number of varieties of the *Salmo* family which have been attributed to the Columbia River will experience considerable shrinkage when the bottom facts come to be known. As a case in point, I think it now safe to state that the *Salmo Gairdneri* and the *Salmo truncatus*, hitherto supposed to be two most unmistakably distinct species, will be found to be one and the same variety—the *Salmo Gairdneri* being the *Salmo truncatus* when prime, and *vice versa*, the *Salmo truncatus* being the *Salmo Gairdneri* at the spawning

season. Other synonyms equally startling will, I think, be established as the study of the Pacific coast salmon progresses.

I must not close this report without expressing my appreciation of the invaluable assistance which was rendered this enterprise on the Clackamas River by Louis Barin, esq., mayor of Oregon City. From the beginning of the work to the end Mr. Barin has been a stanch and efficient friend of the undertaking, and has spared no pains and no exertion to help it on, and it is hardly overstating the matter to say that without his very efficient help our operations on the Clackamas could not have been made nearly as successful as they were this season.

The Oregon and Washington Fish Propagating Company intend to resume their labors next year at the Clackamas hatching-station, and to continue them indefinitely. This they will undoubtedly be able to do by means of the revenue which they expect to derive from State licenses of seines, drift-nets, traps, boats, and other implements used for the capture of salmon in the Columbia River. Washington Territory, which borders on the north bank of the Columbia, has already passed a bill providing for such licenses, a copy of which is here presented, and without doubt the legislature of Oregon will pass a similar bill at its next session this fall (1878).

The following is the act passed by the legislature of Washington Territory to encourage the establishment of salmon-hatching houses on the waters of the Columbia River:

[H. B. 118, substitute for H. B. 107.]

"SECTION 1. *Be it enacted, &c.*, That a fish commissioner for the Columbia River and its tributary waters be appointed by the governor, by and with the advice and consent of the council, who shall hold his office for two years, and until his successor is appointed and qualified, who shall be a resident of one of the counties bordering upon the said river. Said commissioner shall exercise a general supervision over the fisheries of said river within this Territory, consider and report upon the introduction, production, and culture of food-fish, especially the salmon, co-operate with the fish commission of the State of Oregon, make report to the legislative assembly at each biennial session thereof, as hereinafter more particularly prescribed, and perform such other duties as may be hereinafter imposed. Before entering upon his duties he shall execute a bond to the Territory of Washington, with two or more sureties, to be approved by the judge of the second judicial district, in the sum of $10,000, conditioned for the faithful performance of his official duties and the disbursement according to law of all money coming into his hands. Said commissioner may appoint deputies, not to exceed one for each county bordering upon said Columbia River, for whose action he shall be responsible upon his official bond.

"SEC. 2. It shall not be lawful to take or fish for salmon for traffic, barter, or sale in the waters of the Columbia River and its tributaries

with either of the appliances regulated and prescribed by the act entitled 'An act regulating salmon fisheries in the waters of the Columbia River,' without first having obtained a license therefor. The rates of said licenses shall be as follows: The owner or owners of each and every boat engaged in taking or catching salmon upon said river and its tributaries with a gill-net shall pay ten dollars for a license for one season. For each and every seine used in fishing for salmon upon said waters, the owner or owners shall pay for such license for one season ten dollars. For every weir or trap used in catching or taking salmon on said river or its tributaries, the owner or owners shall pay for a license for a season fifty dollars. For each and every dip-net used for fishing for salmon in said river and its tributaries, the owner or owners shall pay an annual license of two dollars. Each and every net-tender or fisherman fishing or taking salmon with a gill-net shall be required to pay five dollars for a license for the season. Licenses issued under this act shall be untransferable, and shall be good for the whole season upon any of the waters of the said Columbia River.

"SEC. 3. The licenses aforesaid shall be prepared by said fish commissioner, attested by his official seal. The commissioner shall register the number thereof, to whom issued and for what purpose. Owners of boats receiving license shall cause to be painted in plain, conspicuous figures upon both sides of the outside of the stern of their respective boats, three inches below the wash-board, the number borne upon the license of said boat. A failure or neglect to paint such register number upon such boat, as herein prescribed, shall subject the owner or owners thereof to a penalty of ten dollars, to be recovered in an action before a justice of the peace. The commissioner shall be entitled to charge the following fees, viz: Twenty-five cents for each license to a fisherman, fifty cents for a boat, one dollar for a seine or fish-trap of any kind, and twenty-five cents for a dip-net, which fees shall be reserved out of the moneys by him received for the licenses issued.

"SEC. 4. Any person or persons who, by the foregoing provisions of this act shall be required to take out a license, shall do such act or use such boat, seine, gill-net, weir or trap, dip-net, or fish with gill-net without having first taken out such license therefor as herein required, shall be liable to a penalty of fifty dollars for each and every offense, and shall moreover be required to pay the license fee required by law, to be recovered before a justice of the peace or other court of competent jurisdiction.

"SEC. 5. Any proprietor, managing agent, foreman, or employé in charge of any cannery upon the said Columbia River, employing a fisherman to whom no license has been issued or knowingly purchasing salmon from any person using a boat, seine, net, or fish-trap for which a license is required, without first having taken out said license, shall be liable to a penalty of fifty dollars for each and every offense, to be recovered before a justice of the peace.

"SEC. 6. All moneys received for license, herein referred to, excepting the fees for issuing the same, shall constitute a fund and be exclusively applied to the assistance of a hatching house or houses on the said Columbia River or its tributaries. Any person or persons or incorporated company who shall furnish satisfactory evidence to the said fish commissioner that a hatching house or houses has or have been established by such person or persons or company, and have actually hatched salmon with which said Columbia River is or has been stocked and supplied, the said commissioner shall forthwith pay over to such person or persons or company the said funds: *Provided*, If there be two or more of such hatching-houses in operation by different persons or companies, then such funds shall be distributed *pro rata* according to the number of hatched salmon.

"SEC. 7. The person or persons making complaint of any violation of the provisions of this act, by the failure to take out a license as herein required, or to do and perform other acts as herein prescribed, shall, upon the conviction of the party accused, be entitled to one-half of the penalty recovered. All fines and penalties hereby or herein imposed shall be enforced and collected as other fines and penalties are by law enforced or collected, and justices of the peace or other officers receiving such fines or penalties, after payment of one-half of such penalty so collected to the complainant, shall forthwith pay the remaining half to the fish commissioner, to be applied to the establishment of or assistance of hatching-houses, as provided in section 6 of this act.

"SEC. 8. The said fish commissioner shall biennially, on the 15th day of September, make a report to the governor to be submitted to the legislative assembly, which report shall exhibit the amount of moneys received from licenses, penalties, and other sources, and how applied; the condition, progress, success, &c., of the hatching-houses, hints, suggestions, or information on the subject of food-fish propagation, and such matters as may be valuable in legislation for the protection or preservation of food-fishes, and the salmon fisheries of the Columbia River.

"SEC. 9. No section, proviso, or part of this act shall be considered as valid or operative until the legislature of the State of Oregon shall enact a similar section, proviso, or act, in whole or in part, and from and after the passing of such a law by the State of Oregon, such parts hereof as shall be so enacted, shall immediately go into full force and effect. And the governor of this Territory is hereby requested to transmit an attested copy of this act to the governor of the State of Oregon, requesting him to submit it to the legislature of that State."

XII.—REPORT OF OPERATIONS AT THE UNITED STATES SALMON-HATCHING STATION ON THE M'CLOUD RIVER, CALIFORNIA, IN 1877.

By Livingston Stone.

Charlestown, N. H., *April* 5, 1878.

Hon. Spencer F. Baird:

Sir: I beg leave to report as follows: When I first reached the McCloud River this season, on the 6th of June, I found everything on the grounds in good order; the usual winter's work of getting in wood for the summer, making nets, &c., had been faithfully attended to by Mr. Myron Green, who had remained in charge during my absence. The high water in the river, however, had carried away the current wheel which raised the water supply for the hatching house, and also the piers on which the wheel rested. In order to avoid a similar calamity this year, I at once adopted the plan of resting the wheel on large flat boats made of plank. This plan was ultimately carried out, and up to the time of the present writing has worked admirably. Indeed, I have just received a letter from Mr. Green, dated United States Fishery, McCloud River, California, January 14, 1878, stating that "the boats and wheel were a perfect success." The boats, together with the wheel, rise and fall with the water, so that any rise in the river does not endanger the wheel or interrupt its working. We gain a double advantage from this method, by not only assuring security to the wheel, but also by obtaining a continuous and permanent supply of water for irrigation, which, as we expect to have a large vegetable garden at the fishery in future, is a matter of no small importance.

The operations at the fishery in other respects this season were conducted very much the same as last year, with the exception that two racks were put across the river to obstruct the salmon instead of one, as usual. To explain why this step was required, it will be necessary to go back two or three years in the history of the fishery. On the 9th of December, 1875, President Grant set aside, by proclamation, a tract of land, including the premises of the McCloud River Fishery, as a United States reservation. For some time previous to this event, a Mr. Leschinsky and son had come over to the McCloud River from Shasta to catch salmon with a seine, and sell them in Shasta and neighboring markets. In consequence of having done this, these fishermen somehow acquired the impression that they had established a title to the land on which the United States Fishery was situated. Consequently, when the United States Fishery premises were made a government

reservation, they disputed the right of the United States Fish Commission to carry on its fishing operations there. This opened a warm controversy, which was carried on for over two years, during which time several unpleasant and rather exciting altercations took place. I was, nevertheless, able, in one way or another, to maintain the rights of the United States Fish Commission in the matter until the land was surveyed. When this was done, by some accident the disputed territory, to our great dismay, was made to come outside of the limits of the United States reservation. I saw the danger at once. Mr. Leschinsky now had, to all appearances, a legal right to keep us off the fishing grounds; and of course, if he did so, no salmon could be obtained for spawning, and the season's labors would be a failure, unless some new plan of operations obviating the difficulty was put into practice. It was this that led to the building of the additional rack just mentioned. Seeing that, in the existing situation, we should be cut off from securing the salmon when they collected below the usual location of our rack, I immediately proceeded to build a rack higher up the river, at a point which would cause some of the salmon at least to collect on what was unquestionably the reservation premises according to the survey, so that if we should not get any spawning salmon from the usual fishing ground, the season would not be an entire failure. This rack was finished, and the river closed to the ascent of the salmon above this point, on the 11th of July. The leaving out of the fishing ground from the reservation proved afterward to be the result of a clerical error, which was rectified during the summer, and the regular fishing ground having been restored to the United States Fish Commission, I then built the usual rack at its accustomed place.

In the mean time the United States had brought a suit against the Leschinskys for trespassing on government property, and in a conversation with them on the subject they expressed themselves willing to desist from fishing out the spawning salmon which were collecting on the fishing ground. As long as I remained at the McCloud they appeared disposed to comply with my wishes in this respect. As soon, however, as I left the river they began to fish again, and on my arrival at Portland, Oreg., I received a dispatch from Mr. Green, who was left in charge at the McCloud River, stating that the Leschinskys were fishing again on the reservation and had expressed a determination to continue to fish there as long as they pleased. Under these circumstances I concluded to do what I had had for a long time in contemplation, viz, to apply for a small guard of soldiers to occupy the reservation fishing grounds during the fishing season. My object in doing this was threefold. In the first place, it would secure beyond any doubt the safety of the spawning salmon, and, in the second place, it would impress upon the minds of the community about there the fact that the fishery grounds were United States property, a circumstance which seemed to be very coolly ignored in some portions of our neighborhood.

My third and chief reason for having a military guard on the reservation was to avoid a collision between the Leschinsky party and my own; not that I thought that we were not strong enough to overpower the opposing party, if necessary, but I wanted to avoid this very necessity, and in case of trouble, instead of engaging in a personal quarrel, to throw the burden of defending the rights and property of the United States upon those whose business it was to render such defense.

On the 16th of August the soldiers arrived, a lieutenant and four men; and from that time our breeding salmon were not molested. On the 1st of October the United States marshal removed Mr. Leschinsky and son from the reservation.

This matter was hardly set right before another difficulty, quite as serious, presented itself. When the time came, about the 1st of September, for our large run of salmon to appear in the McCloud, we were very much disappointed and not a little alarmed to find that the salmon came in extremely small numbers, although, owing to the supply of young salmon which we put in the river three years ago, there was an unusually large number running in the Sacramento. At first we could not understand it. The mystery was soon solved, however, by the discovery that parties engaged in the business of canning salmon on the Sacramento were continuing to fish illegally beyond the close time assigned by the law of the State. As this fishing is done with great numbers of drift-nets at a time, about every salmon on the river of any considerable size is caught; and, in consequence of this, only a few stragglers which escaped the nets of the canners had reached the McCloud hatching station. Here was real cause for alarm; for if this illegal fishing were not stopped immediately, nearly all the spawning salmon for the season would be intercepted at the canneries, and very few would reach the McCloud River to furnish eggs for the hatching establishment. In this emergency the California Fish Commissioners came to the rescue, and with their characteristic energy and resolution stopped the illegal fishing, and pushed the suit against the canners with so much vigor that in less than six weeks they were tried, convicted, and fined to the amount of nearly a thousand dollars.

It was too late, however, for us to retrieve our losses at the fishery. The salmon that we should have had to yield our annual harvest of eggs were already in the tin cans of the law-breaking cannery men, and we had to make the best of the comparatively few breeders which succeeded in reaching the McCloud. At this juncture, the first rack which was built across the river, under a misapprehension, and which had been looked upon as a useless expenditure, played a most serviceable part; for, as has been mentioned, this rack closed up the river the 11th of July, which is much earlier than the river is usually obstructed. The consequence was that quite a large number of salmon collected below this rack before the regular rack was put across, and formed a reserve of which we now very gladly availed ourselves, and without which

we should have taken a very scanty supply of eggs. As it was, we began spawning the salmon on the 28th of August, on which day we obtained 28,000 eggs, and continued taking eggs till the 19th of September, when we took the last of the regular season's supply. We continued fishing, however, to procure a supply of spawners for the eggs which were to go to Australia and New Zealand, it being necessary to take these just twenty days before the Australian steamer sails from San Francisco, so that they will, at starting, be neither so young that they cannot be packed without injury, nor so far advanced that they will hatch out on the journey. These eggs were all taken on the 18th and 19th of September.

The experiment, which was tried for the first time last year, of shipping the salmon across the continent in a refrigerator-car, or rather a common box-car filled with ice, proved a very marked success; hardly more than two per cent. of the eggs being killed by the journey. I decided, therefore, to use the same method of transportation again this season, and on the 26th of September Mr. Pratt went to Sacramento for the car and brought it to Redding, where it was loaded during the 29th and 30th of September and 1st of October, and from which point it was dispatched on the 2d day of October with the passenger-train for Sacramento. On the same afternoon it left Sacramento with the overland passenger-train, and reached Chicago on the 7th of October, where the crates containing the eggs were received and forwarded by the United States Express Company to their various points of destinations. I will give a short quotation below from Mr. Pratt's letter in regard to loading the car:

"UNITED STATES FISHERY, *October* 4, 1877.

"MY DEAR MR. STONE: I went down to Sacramento on the 26th, but left here on the 25th, as it was necessary for me to stop at Stillwater and see about the teams that were to haul the eggs to Redding, as we had not received an answer from one of the parties (Mr. Smithson). I mailed the letters to the consignees the 26th from Redding. On arriving at Sacramento I found the car already there, but there was no use in taking it up to Redding until the next day.

"On the morning of the 28th I had the car sent around to the ice-house, and, having secured permission from the railroad authorities, had the ice all packed in one end of the car, 6½ tons, and used thirteen barrels of sawdust to pack around it. On reaching Redding you could not see that the ice had melted a particle. I found three loads of salmon eggs standing on the platform at the freight depot, and after packing with ice the one crate going by express to Salt Lake City, I went to work and loaded the remaining crates into the car and iced them all. Had engaged a man to help me, and to look after the car while it remained at Redding.

"Mr. O'Brien had brought down one load and he assisted us in pack-

ing. The next morning I came out to the fishery on one of the teams, staid here until the next night, and then went down on the stage to Redding, where, on arriving, I found the three teams were there before me and unloaded. So we went right to work and loaded the crates into the cars, and filled the ice chambers. Then I went to bed, just at daylight, and slept a few hours, and in the afternoon we worked in the car, refilling the ice chambers that had been filled on the first day the car reached Redding, and packing a box of specimens of trout and young salmon for the Smithsonian Institution. There were five jars, and I packed them solidly in sawdust, and marked them Prof. S. F. Baird, Smithsonian Institution, Washington, D. C., in full.

"The ice in the chambers filled two days before had melted only a little, but I went over them all, and gave them all the ice they would take. I packed the crates on both sides of the car, leaving a passage-way the whole length in the center. Piled ice on top of the crates nearly to top of car, in some places quite; then had several cakes left, which I put in the passage-way and on the small crates which were put there too. Returned to Sacramento on the 2d, having sent telegrams to all the consignees. Had the car taken around to ice-house and took on only a little over a ton of ice, as there was no room for any more without blocking up the whole car, which I could not think was necessary.

"Besides the salmon eggs which consisted of thirty-nine crates, to be distributed by the express company, there were twelve crates for Mr. Fred Mather to take charge of. We understood from Professor Baird's telegram that he wanted the eggs for Europe packed in separate lots of 25,000 each, and so packed them. We gave the Netherlands 100,000, as he directed; England, 50,000; France, 50,000; Germany, 50,000; Prussia, 50,000. The orders Professor Baird sent we cut down about 50 per cent.; that is, the larger ones. Those for 50,000 and 100,000 we did not cut down.

"Very truly, yours,

"KIRBY B. PRATT."

On the 7th of October the eggs for New Zealand and Australia were sent to San Francisco to go on the steamer leaving that point on the 9th of October.

In the mean time and as long as the state of the river permitted, Mr. Green continued to fish and take eggs, and succeeded so well that several new lots were sent off and a balance of over 2,000,000 left to be hatched and returned to the tributaries of the Sacramento.

It may not be out of place to mention here that although the salmon are increasing in the Sacramento,* it is nevertheless true that the yearly

* "Salmon have been more plentiful in the Sacramento this year than ever before, and never has such a vast quantity of salmon been taken."—(Letter from Hon. B. B. Redding, secretary of California Fish Commission, dated October 1, 1877.)

supply of young fish comes mainly from the hatching station on the McCloud River, and that consequently that supply must be kept up. If this is neglected the Sacramento will be depleted of salmon, and the efficiency of the salmon hatching station on the McCloud will be very much impaired, if not entirely destroyed. It accordingly becomes imperative on the part of the United States Fish Commission to return to the tributaries of the Sacramento a certain number of young salmon annually, say from 1,000,000 to 2,000,000, to maintain its own existence.

As the California fish commission will cheerfully pay the cost of hatching the salmon allowed for this purpose, I cordially recommend that this be done every year.

In concluding, I will say that the reports from the parties receiving salmon eggs from the McCloud station last year were extremely satisfactory in regard to the condition of the eggs on arrival at their destinations. With the exception of a small lot sent to the New York Aquarium, I believe the loss in transportation did not exceed $2\frac{1}{2}$ per cent. Even the eggs which were sent eight thousand miles and across the equator to New Zealand and Australia, arrived in fine order and with very slight loss.

In confirmation of the above statements, I take the liberty to present the following letters received from several gentlemen to whom California salmon eggs were consigned last year and the year previous:

OFFICE OF FISH COMMISSIONERS, STATE OF MINNESOTA,
Saint Paul, October 9, 1876.

DEAR SIR: The salmon eggs assigned to our State came safely on the 5th, and were *in fine condition*, for which accept our thanks.

Very respectfully,

R. O. SWEENY,
Chairman Fish Commission.

LIVINGSTON STONE, Esq.,
United States Fishery, Redding, Cal.

NEW HOPE, PA., *October* 9, 1876.

DEAR SIR: I received the 75,000 California salmon eggs on Thursday last; they were *in splendid order*, there being only 1,800 dead eggs in the lot; and have only lost since 142 eggs.

Truly yours,

J. B. THOMPSON.

LIVINGSTON STONE, Esq.

BELLEVILLE, ILL., *October* 13, 1876.

DEAR SIR: The Belleville Fishing Club received 100,000 California salmon eggs on the 5th instant. The eggs were well packed and *in excellent order.* They have been placed in the hatching-troughs, and are hatching very satisfactorily.

Most respectfully, yours,

LOUIS C. STARKEL.

LIVINGSTON STONE, Esq.,
Charlestown, N. H.

WESTPORT, FAIRFIELD COUNTY, CONN.,
October 16, 1876.

DEAR SIR: I am happy to inform you that our consignment of salmon eggs was received in good condition, *less than 2 per cent. being dead.*

Yours, truly,

E. M. LEES.

L. STONE, Esq.

MADISON, WIS., *December* 11, 1876.

DEAR SIR: The California salmon eggs are now hatched. *A better lot of eggs were never taken from fish.* You and your assistants are entitled to great credit for the skill and care with which they were handled.

Truly yours,

W. WELCH,
Fish Commission.

LIVINGSTON STONE, Esq.

OHIO STATE FISH HATCHERY,
Toledo, Ohio, October 13, 1877.

MY DEAR SIR: The consignment of 250,000 California salmon eggs reached me on Thursday last, October 9, in good condition, *not over one in five hundred being spoiled.* They were at once placed in the hatchery here, where they are doing well.

Very truly,

EMERY D. POTTER.

LIVINGSTON STONE, Esq.

ELGIN, *December* 17, 1877.

MY DEAR SIR: The California salmon eggs *came in very nice shape* and hatched with but small loss.

Yours,

W. A. PRATT.

LIVINGSTON STONE.

NEW HOPE, PA., *January* 16, 1878.

DEAR SIR: The salmon have all done unusually well this year.

Truly yours,

J. B. THOMPSON.

LIVINGSTON STONE, Esq.

When it is remembered that in the case of the consignments to the Eastern States the eggs were packed in the torrid climate of California and traveled, afterward, thirty-six hours within the limits of that State, during a part of which time they were often subjected to a temperature of 120° to 130° Fahrenheit, it will be acknowledged, I think, that the eggs stood the journey of 3,000 miles of rail after leaving California wonderfully well.

It is true that this season a large proportion of the eggs sent to France and Germany, and other points in Europe, arrived in poor condition; but this was undoubtedly the result of their not having been kept cold enough after reaching the eastern slope of the United States. The loss of the eggs could not with any show of reason be attributed to the packing, for it is perfectly obvious that a method of packing which will take California salmon eggs in fine order across the Equator almost 8,000 miles, to New Zealand and Australia, is amply competent to carry them in safety, in the cool month of October, the shorter distance across the Atlantic, the whole of which is included in the temperate zone. The trouble was that at some point *en route* the temperature of the crates of eggs was allowed to rise above the limit of safety, and that is destruction to salmon eggs *in transit*, no matter how they are packed. Had the European consignment of salmon eggs been kept *cold enough*, they would have not only arrived in good condition in Europe, but *could have been sent back to California in safety.*

I might offer a dozen proofs of this statement, but will confine myself to the following extract from a New Zealand paper in reference to the California salmon eggs sent to that country from the United States station at the McCloud River last fall, 1877:

[From the Lyttellon Times, Christchurch, New Zealand, November 14, 1877.]

"FISH CULTURE AT OPAWA.—The Wellington consignment of American salmon ova for Mr. Johnson arrived on Saturday last by the "Rotura."

"The *splendid condition* in which they have arrived reflects great credit on those in America who had charge of the collecting and packing, which, in several respects, is an improvement on the English method."

Mr. Myron Green and Mr. Kirby B. Pratt, acting under my instructions, carried on the work at the McCloud River during my absence in Oregon, and deserve great credit for the faithful and efficient manner in which they executed their labors, and also for the very successful results which were accomplished.

It is worth noticing in the table of applications for 1877, and at the same time it reflects very creditably upon the usefulness of the United States station of the McCloud River, that although upward of 30,000,000 salmon eggs have been distributed from there, the demand still very much exceeds the supply.

Table of temperatures taken at the United States salmon-breeding station, McCloud River, California, during the season of 1877.

Date.	Air.				Water.			Wind.			Weather.
	Shade.			Sun.							
	7 a. m.	3 p.	7 p. m.	3 p. m.	7 a. m.	3 p. m.	7 p. m.	7 a. m.	3 p. m.	7 p. m.	
1877.	°	°	°	°	°	°	°				
May 1	49	78	62	102	50	56	55	......	......	......	Clear.
2	47	83	62	102	50	55	54	......	......	......	Cloudy.
3	58	87	64	114	51	57	56	......	......	......	Clear.
4	60	84	68	110	51	57	56	......	......	......	Do.
5	63	86	64	108	52	58	57	......	......	......	Do.
6	52	76	63	100	52	58	57	Windy and cloudy.			Thunder shower.
7	46	56	46	......	50	53	52	......	......	......	Rainy.
8	41	54	52	96	48	51	50	......	......	......	Cloudy.
9	44	76	60	102	48	54	53	......	......	......	Do.
10	53	80	62	110	50	56	55	......	......	......	Clear.
11	50	84	63	116	52	57	56	......	......	......	Do.
12	53	66	60	......	52	55	54	......	......	......	Do.
13	52	60	52	......	51	52	51	......	......	......	Cloudy; p. m. rainy.
14	50	58	64	......	49	54	54	......	......	......	Cloudy.
15	52	64	56	......	51	54	53	......	......	......	Cloudy; p. m. rainy.
16	50	71	66	......	50	54	54	......	......	......	Cloudy.
17	58	78	58	92	52	56	56	......	......	......	Do.
18	59	78	62	102	51	56	55	Windy.			Clear.
19	56	74	62	98	50	57	56	......	......	......	Do.
20	51	62	58	......	51	52	52	......	......	......	Do.
21	49	58	50	......	49	52	52	P. m. windy.			Cloudy.
22	45	66	56	80	47	52	52	......	......	......	Do.
23	52	76	60	100	48	56	55	......	......	......	Clear.
24	52	80	64	104	50	56	55	......	......	......	Do.
25	53	75	62	......	51	57	56	......	......	......	Do.
26	60	74	61	99	52	58	57	......	......	......	Cloudy.
27	58	76	62	100	52	57	56	P. m. cloudy.			Clear.
28	48	52	51	......	51	52	51	......	......	......	Heavy rain.
29	50	64	50	......	50	54	53	......	......	......	Rain.
30	54	71	60	98	50	55	54	......	......	......	Clear.
31	60	74	62	104	50	57	56	......	......	......	Do.
June 1	65	87	61	108	52	58	57	......	......	......	Do.
2	62	76	69	104	52	58	57	......	......	......	Do.
3	61	84	70	108	52	56	56	......	......	......	P. m. cloudy.
4	64	76	74	......	53	58	57	......	......	......	Do.
5	64	82	64	108	52	59	50	......	......	......	Clear.
6	63	83	76	109	53	59	58	......	......	......	Do.
7	52	90	70	113	54	58	58	......	......	......	Do.
8	52	94	74	118	54	60	59	......	......	......	Do.
9	54	99	76	124	58	62	62	......	......	......	Do.
10	68	100	84	126	54	62	62	......	......	......	Do.
11	56	102	86	124	56	62	62	......	......	......	Do.
12	76	100	75	126	56	62	61	......	......	......	Do.
13	74	96	78	125	55	62	61	......	......	......	Do.
14	68	96	74	123	54	62	61	......	......	......	Do.
15	64	91	72	112	54	61	60	......	......	......	Do.
16	63	82	71	107	55	61	60	......	......	......	Do.
17	62	90	70	115	55	62	61	......	......	......	Do.

Table of temperatures taken at McCloud River, California, &c.—Continued.

Date.	Air.				Water.			Wind.			Weather.
	Shade.			Sun.							
	7 a. m.	3 p. m.	7 p. m.	3 p. m.	7 a. m.	3 p. m.	7 p. m.	7 a. m.	3 p. m.	7 p. m.	
1877.	°	°	°	°	°	°	°				
June 18	68	89	72	106	55	62	61	......	......	......	Clear.
19	68	88	70	116	55	62	61	......	......	......	Do.
20	69	91	70	119	55	61	60	......	......	......	Do.
21	66	88	73	112	55	61	60	......	......	......	Do.
22	63	83	74	110	54	61	60	......	......	......	Do.
23	66	81	68	106	54	61	60	......	......	......	P. m. cloudy.
24	63	83	70	104	53	59	58	......	......	......	Do.
25	67	84	64	104	52	58	58	......	......	......	Rain.
26	62	70	68	......	52	56	58	......	......	......	Do.
27	56	54	54	......	52	52	52	......	......	......	Cloudy.
28	54	62	56	86	50	53	53	......	......	......	Clear.
29	56	73	64	93	50	57	56	......	......	......	Do.
30	60	79	68	103	53	60	60	......	......	......	Do.
July 1	62	84	69	110	53	60	59	......	......	......	Do.
2	66	84	76	102	54	60	60	......	......	......	Clear; p. m. cloudy.
3	60	70	64	92	54	59	58	......	......	......	Clear.
4	66	73	64	100	52	58	57	......	......	......	Do.
5	58	78	68	96	53	58	58	......	......	......	Do.
6	60	82	70	110	52	59	59	......	......	......	Do.
7	66	89	70	110	54	60	59	......	......	......	Do.
8	63	90	72	110	53	60	60	......	......	......	Do.
9	63	91	74	115	54	60	60	......	......	......	Do.
10	60	89	82	128	54	60	60	......	......	......	Do.
11	62	94	78	136	55	61	61	......	......	......	Do.
12	72	98	80	124	54	62	62	......	......	......	Do.
13	78	102	81	134	56	63	63	......	......	......	Do.
14	80	98	86	124	56	62	62	......	......	......	Do.
15	76	92	80	110	56	62	62	......	......	......	Cloudy and rainy.
16	72	76	75	......	56	59	59	......	......	......	Rainy.
17	68	90	76	122	56	60	60	......	......	......	Clear.
18	72	93	98	121	56	62	62	......	......	......	Do.
19	76	96	78	128	56	62	62	......	......	......	Cloudy.
20	71	88	81	......	56	59	59	......	......	......	Clear.
21	76	96	90	114	54	60	60	......	......	......	Do.
22	79	95	87	121	55	61	60	......	......	......	Do.
23	75	97	83	125	56	61	61	......	......	......	Do.
24	68	96	80	123	56	61	61	......	......	......	Do.
25	72	93	78	116	56	61	61	......	......	......	Do.
26	68	95	78	126	56	61	61	......	......	......	Do.
27	68	100	79	130	56	61	61	......	......	......	Do.
28	69	96	77	123	56	61	61	......	......	......	Do.
29	71	90	80	107	56	61	61		Windy.		Do.
30	71	89	78	117	55	60	60	......	......	......	Do.
31	70	94	76	120	56	60	60	......	......	......	Do.
Aug. 1	64	95	74	117	54	60	60	S. W.	S. W.	Calm.	Do.
2	60	84	79	112	54	60	60	S. W.	S. W.	Calm.	Do.
3	62	84	79	107	54	60	60	S. W.	S. W.	Calm.	Do.
4	70	92	75	120	54	60	60	N. W.	S. W.	S. W.	Do.
5	66	93	74	123	54	60	59	S. W.	S. W.	Calm.	Do.
6	63	95	73	124	54	60	59	S. W.	S. W.	Calm.	Do.
7	58	96	74	119	54	60	60	S. W.	S. W.	Calm.	Do.
8	54	90	72	110	54	59	58	S. W.	S. W.	Calm.	Do.
9	63	91	72	108	54	58	58	N. E.	Calm.	Calm.	Cloudy and sultry.
10	53	92	75	114	52	58	58	N. E.	S. W.	Calm.	Clear.
11	49	94	73	116	53	59	59	N. E.	S. W.	Calm.	Do.
12	56	96	72	118	53	58	58	N. E.	S. W.	Calm.	Do.
13	60	96	73	122	53	58	58	N. E.	S. W.	Calm.	Do.
14	56	98	76	125	53	59	59	N. E.	S. W.	Calm.	Do.
15	61.	96	74	117	54	59	59	N. E.	N. E.	Calm.	Do.
16	56	92	76	117	53	58	58	S. W.	S. W.	S. W.	Cloudy.
17	59	92	72	114	53	58	58	Calm.	S. W.	S. W.	Thunder and lightning; at night clear.
18	55	92	72	109	54	59	50	Calm.	Calm.	S. W.	Clear.
19	52	88	72	113	53	59	59	S. W.	S. W.	Calm.	Do.
20	50	88	80	106	54	58	58	N. E.	S. W.	Calm.	Do.
21	50	92	72	118	55	58	58	N. E.	S. W.	Calm.	Do.
22	50	89	72	104	54	58	58	N. E.	S. W.	Calm.	Do.
23	47	84	71	107	53	58	58	Calm.	S. W.	S. W.	Do.
24	49	62	60	......	53	54	54	N. E.	N. E.	N. E.	Rain.
25	48	80	64	108	50	56	56	Calm.	S. W.	Calm.	Clear.
26	48	89	67	117	50	57	57	N. E.	N. E.	Calm.	Do.
27	45	92	66	113	50	56	56	Calm.	S. W.	Calm.	Do.
28	42	90	66	113	51	56	56	Calm.	S. W.	Calm.	Do.

Table of temperatures taken at McCloud River, California, &c.—Continued.

Date.	Air. Shade. 7 a. m.	Air. Shade. 3 p. m.	Air. Shade. 7 p. m.	Air. Sun. 3 p. m.	Water. 7 a. m.	Water. 3 p. m.	Water. 7 p. m.	Wind. 7 a. m.	Wind. 3 p. m.	Wind. 7 p. m.	Weather.
1877.	°	°	°	°	°	°	°				
Aug. 29	52	74	63	100	52	55	55	Calm.	S. W.	Calm.	Rain; cloudy.
30	50	90	69	118	52	57	57	Calm.	S. W.	Calm.	Clear.
31	49	91	70	114	52	56	58	Calm.	S. W.	Calm.	Do.
Sept. 1	46	92	66	114	52	57	57	Calm.	N.	Calm.	Do.
2	49	94	70	118	52	57	57	Calm.	Calm.	Calm.	Do.
3	53	99	72	122	53	58	58	Calm.	N.	Calm.	P. m. cloudy.
4	56	100	79	124	53	58	58	Calm.	S.	Calm.	Clear.
5	54	94	70	118	54	58	58	Calm.	Calm.	Calm.	Do.
6	58	92	72	114	54	58	58	N.	N.	N. E.	Do.
7	55	94	70	123	52	57	57	N.	N.	N.	Do.
8	50	94	68	121	52	56	56	N.	N.	Calm.	Do.
9	51	93	72	110	52	56	56	Calm.	S. W.	Calm.	Clouds.
10	52	82	71	106	52	56	56	N. E.	N. E.	N. E.	Do.
11	50	78	74	104	52	54	54	N. E.	N. E.	N. E.	Do.
12	42	76	74	100	50	55	55	N. E.	N. E.	N. E.	Cloudy.
13	55	82	70	91	49	56	56	N. E.	N. E.	N. E.	Clear.
14	57	88	70	110	50	57	57	N. E.	N. E.	N. E.	Do.
15	56	91	72	116	51	57	57	N. E.	N. E.	N. E.	Do.
16	59	93	72	116	53	56	56	N. E.	N. E.	N. E.	Do.
17	57	96	70	124	52	56	56	N. E.	N. E.	Calm.	Do.
18	56	96	70	120	51	56	56	N. E.	S.	Calm.	Do.
19	52	92	68	116	51	56	56	N. E.	Calm.	Calm.	Do.
20	54	84	72	96	51	55	55	S. W.	S. W.	S. W.	Do.
21	49	84	62	106	50	55	55	S. W.	....	Calm.	Slight clouds.
22	48	80	64	96	51	54	54	S. W.	....	Calm.	Clear.
23	41	80	62	106	50	53	53	S. W.	....	Calm.	Do.
24	42	82	60	100	49	52	52	N. E.	N. E.	Calm.	Do.
25	43	82	59	104	50	53	53	S.	N. E.	S. W.	Do.
26	46	84	67	110	50	54	54	N. W.	N. E.	S. W.	Do.
27	46	84	70	110	50	54	54	N. E.	N. E.	Calm.	Cloudy.
28	46	82	75	84	50	54	54	N. E.	N. E.	S. W.	Clear.
29	46	84	62	110	50	54	54	N. E.	N. E.	Calm.	Do.
30	42	80	56	108	49	52	52	N. E.	N. E.	N. E.	Do.
Oct. 1	54	74	62	107	49	52	52	S.	S.	N. E.	Do.
2	42	72	62	110	48	52	52	N. E.	N. E.	N. E.	Do.
3	44	73	60	108	48	52	52	N. E.	N. E.	Calm.	Do.
4	46	78	59	107	49	53	53	N. E.	N. E.	Calm.	Do.
5	48	84	68	106	49	53	53	N. E.	N. E.	Calm.	Do.
6	55	86	56	112	50	54	54	N. E.	N. E.	N. E.	Slight clouds.
7	56	88	62	118	50	54	54	N.	N. E.	N. E.	Do.
8	48	91	62	110	50	53	53	N. E.	N. E.	N. E.	Do.
9	46	86	62	112	49	54	54	N. E.	S. W.	N. E.	Cloudy.
10	44	83	74	88	49	52	52	N. E.	S. W.	S.	Do.
11	44	75	60	77	49	52	52	N.	S. W.	S. W.	Do.
12	44	66	60	......	49	52	52	N.	S. W.	S. W.	Do.
13	54	70	56	......	48	50	50	S. W.	S. W.	S. W.	Do.
14	43	80	53	102	48	51	51	S. W.	N. W.	Calm.	Do.
15	36	83	53	114	47	50	50	Calm.	N. W.	Calm.	Do.
16	42	80	54	112	46	49	49	N. E.	N. W.	Calm.	Do.
17	43	82	52	114	46	49	49	N. E.	N. W.	Calm.	Do.
18	42	80	50	110	47	50	50	N. W.	N. W.	Calm.	Do.
19	36	79	52	98	46	49	49	N. W.	W.	Calm.	Do.
20	36	70	58	......	46	49	49	Calm.	S. W.	S. W.	A. m. rain; p. m. cl'dy.
21	50	63	54	81	47	49	49	S. W.	N. W.	S. W.	Do.
22	54	54	52	......	48	49	49	S.	S.	S. W.	Cloudy.
23	50	59	56	......	49	50	50	Calm.	S.	Calm.	Hazy; cloudy.
24	49	67	56	70	49	51	51	Calm.	S. W.	S. W.	A. m. rain; p. m. clear.
25	54	66	54	80	50	51	51	Calm.	N. E.	Calm.	Sun-shower; clear.
26	42	68	46	93	49	51	51	N. E.	N. E.	N. E.	Clear.
27	36	61	46	80	46	48	48	N. E.	N. E.	N. E.	Do.
28	32	61	46	82	44	46	46	Calm.	N. E.	N. E.	Do.
29	31	64	39	88	44	46	46	N. E.	N. E.	N. E.	Do.
30	32	65	40	84	44	46	46	N. E.	N. E.	N. E.	Do.
31	31	64	39	85	44	46	46	N. E.	N. E.	N. E.	Do.
Nov. 1	40	52	46	76	44	45	45	Calm.	W.	Calm.	Do.
2	48	48	48	......	44	45	45	Calm.	S. W.	....	Rain a. m.
3	46	52	46	......	46	46	46	Calm.	S. W.	....	Do.
4	48	50	50	......	47	48	48	Calm.	S. W.	....	Rain.
5	52	55	55	......	43	48	48	S. W.	S. W.	S. W.	Do.
6	38	56	54	......	47	48	48	Fog...	....	S. W.	Cloudy.
7	38	64	50	88	46	48	48	N. E.	N. E.	N. E.	Clear.
8	41	65	51	......	46	48	48	N. E.	....	....	Clear a. m.; cl'dy p.m.
9	38	71	50	75	46	48	48	N. W.	N. W.	N. W.	Clear.

Table of temperatures taken at McCloud River, California, &c.—Continued.

Date.	Air.				Water.			Wind.			Weather.
	Shade.			Sun.							
	7 a. m.	3 p. m.	7 p. m.	3 p. m.	7 a. m.	3 p. m.	7 p. m.	7 a. m.	3 p. m.	7 p. m.	
1877.	°	°	°	°	°	°	°				
Nov. 10	38	54	50	......	44	46	46	S. W.	S. W.	S. W.	Cloudy.
11	48	53	47	......	46	48	48	S. W.	S. W.	S. W.	Rain.
12	36	61	47	70	46	48	48	Fog ...	N.	....	Clear.
13	34	54	47	......	44	44	44	S. W.	....	N. E.	Cloudy.
14	46	48	47	......	46	46	46	S. W.	S. W.	....	Rain.
15	48	54	53	......	47	47	47	....	S. W.	Calm.	A. m. rain; cl'ds p. m.
16	54	62	54	70	47	50	50	....	W.	S. W.	Clear.
17	36	63	52	65	47	48	48	N. W.	N. W.	N.	Do.
18	44	63	50	73	46	43	48	N. W.	N. W.	N. W.	Do.
19	40	69	54	75	46	48	48	N. W.	N. W.	Calm.	Do.
20	37	70	42	75	45	46	46	N. E.	N. W.	Calm.	Cloudy.
21	42	52	50	......	44	45	45	S. W.	S. W.	Calm.	Rain.
22	48	52	52	......	46	47	47	S. W.	S. W.	S. W.	Clear.
23	53	62	50	67	48	48	48	N.	N.	S. W.	Do.
24	36	61	50	66	46	47	47	N. W.	....	Calm.	Do.
25	36	62	48	63	46	47	47	N. W.	N. W.	Calm.	Do.
26	38	61	50	65	45	47	47	N. W.	N. W.	Calm.	Do.
27	36	70	52	75	45	47	47	N. E.	N. E.	Calm.	Do.
28	40	73	44	81	44	46	46	Calm.	N. W.	Calm.	Do.
29	40	72	46	80	44	46	46	Calm.	N. W.	Calm.	Do.
30	32	67	42	71	44	46	46	Calm.	N.	Calm.	Do,
Dec. 1	40	59	40	64	44	46	46	Calm.	N.	....	Do.
2	33	64	38	72	44	46	46	....	N. W.	N. W.	Do.
3	28	64	40	74	43	44	44	....	....	....	Do.
4	40	65	40	80	42	44	44	S. W.	....	....	Do.
5	26	62	36	82	41	43	43	N. W.	N. W.	....	Do.
6	28	63	37	81	41	43	43	....	N. W.	....	Do.
7	31	64	38	76	41	43	43	N. W.	N. W.	....	Do.
8	30	64	41	76	41	43	43	....	N. W.	....	Do.
9	38	59	38	68	41	43	43	....	S. W.	S. W.	Do.
10	38	59	40	76	41	43	43	....	N. E.	S. W.	Do.
11	38	46	40	......	42	44	44	....	S. W.	S. W.	Rain.
12	38	59	38	68	43	45	45	S. W.	S. W.	S. W.	Do.
13	40	60	40	72	44	46	46	S. W.	....	....	Clear.
14	42	63	40	74	44	46	46	....	....	....	Do.
15	42	62	41	82	44	46	46	....	....	....	Do.
16	40	45	40	......	44	46	46	....	....	....	Rain.
17	39	48	42	......	44	46	46	....	....	....	Do.
18	39	59	40	76	44	46	46	....	....	....	Clear.
19	38	50	48	......	45	46	46	....	S. W.	S. W	Fog.
20	38	56	50	......	45	46	46	S. W.	S. W.	S. W.	Fog; cloudy.
21	47	52	47	65	47	48	48	S. W.	Calm.	....	Fog and rain.
22	35	44	44	......	45	46	46	....	....	....	Rain.
23	37	41	40	......	45	45	45	....	....	....	Clear.
24	36	56	38	72	44	45	45	....	....	....	Cloudy.
25	38	48	40	......	44	45	45	....	....	....	Do.
26	32	53	40	......	44	45	45	N. E.	N. E.	....	Clear.
27	36	57	36	72	43	44	44	N. W.	N. W.	....	Do.
28	26	56	36	70	41	43	43	N. E.	N. E.	N. E.	Do.
29	29	58	36	70	41	43	43	N. E.	N. E.	N. E.	Do.
30	32	56	35	70	41	43	43	N. E.	N. E.	N. E.	Do.
31	25	50	30	68	40	42	42	N. W.	N. W.	N. W.	Do.

Table of salmon eggs taken at the United States breeding station, McCloud River, California, during the season of 1877.

Date.	Number of eggs taken.	Total number of eggs taken.	Number of salmon spawned.	Total number of salmon spawned.	Date.	Number of eggs taken.	Total number of eggs taken.	Number of salmon spawned.	Total number of salmon spawned.
Aug. 21	5, 000	....	1	....	Sept. 10	322, 000	3, 456, 000	73	818
23	4, 000	9, 000	1	2	11	420, 000	3, 876, 000	105	923
25	19, 000	28, 000	4	6	12	708, 000	4, 584, 000	164	1, 087
28	65, 000	93, 000	17	23	15	471, 000	5, 055, 000	124	1, 211
30	121, 000	214, 000	32	55	17	225, 000	5, 280, 000	58	1, 269
31	185, 000	399, 500	42	97	19	240, 000	5, 520, 000	59	1, 328
Sept. 1	246, 000	645, 500	63	160	20	148, 000	5, 668, 000	36	1, 364
2	266, 500	912, 000	63	223	21	72, 000	5, 740, 000	18	1, 382
3	226, 500	1, 138, 500	54	277	22	89, 000	5, 829, 000	25	1, 407
5	519, 500	1, 658, 000	114	391	24	84, 000	5, 913, 000	20	1, 427
6	296, 000	1, 954, 000	73	464	26	41, 000	5, 954, 000	11	1, 438
7	381, 000	2, 335, 000	99	563	28	59, 000	6, 013, 000	15	1, 453
8	384, 000	2, 719, 000	89	652	Oct. 9	40, 000	6, 053, 000	7	1, 460
9	415, 000	3, 134, 000	93	745	(*)	1, 000, 000	7, 053, 000	....	....

* Subsequent to October 9, daily record not kept. Number of eggs taken estimated at 1,000,000.

Table of distribution of salmon eggs from the United States salmon-breeding station, McCloud River, California, during the season of 1877.

State or country.	Consignee.	No. asked.	No. assigned.	No. forwarded.	Destination.
California	B. B. Redding, F. C	500, 000	300, 000	200, 000	Sacramento River.
Illinois	W. D. E. Andrus	50, 000	50, 000	50, 000	George Lincoln, Rockford.
	W. A. Pratt, M. D........	100, 000	100, 000	50, 000	Elgin.
	Belleville Fishing Club.	50, 000	50, 000	50, 000	L. C. Starkel, Belleville.
Iowa..................	B. F. Shaw, F. C	100, 000	100, 000	100, 000	Anamosa.
Kansas	D. B. Long, F. C	100, 000	100, 000	100, 000	Ellsworth.
Kentucky	Industrial Exhibition ..	10, 000	5, 000	5, 000	Pack Thomas, Louisville.
	William Griffith, F. C...	300, 000	300, 000	150, 000	Louisville.
Massachusetts......	E. A. Brackett, F. C......	300, 000	300, 000	100, 000	100,000 to Winchester; 200,000 to Plymouth, N. H.
Maryland..........	T. B. Ferguson, F. C	2, 500, 000	500, 000	400, 000	Baltimore.
Minnesota..........	R. O. Sweeny, F. C.......	600, 000	500, 000	250, 000	Saint Paul.
Michigan...........	George H. Jerome, F. C.	300, 000	300, 000	150, 000	Niles.
New Jersey.........	J. R. Shotwell, F. C	500, 000	500, 000	250, 000	Mrs. J. H. Slack, Bloomsbury.
New York	R. B. Roosevelt, F. C	200, 000	200, 000	100, 000	Caledonia (State hatching-house).
	H. H. Porter	10, 000	10, 000	10, 000	Half Way, Onondaga County.
New Hampshire...	Samuel Webber, F. C	200, 000	200, 000	100, 000	*See* E. A. Brackett, Massachusetts.
Nebraska...........	J. G. Roman	10, 000	10, 000	10, 000	South Bend.
Ohio..................	Emery D. Potter, F. C ..	500, 000	500, 000	250, 000	Toledo.
Pennsylvania.......	James Duffy, F. C........	400, 000	400, 000	200, 000	325,000 to J. P. Creveling, for James Duffy, Marietta; 75,000 to Seth Weeks, Corry.
	J. B. Thompson	50, 000	50, 000	50, 000	New Hope.
	......do..................	100, 000	100, 000	100, 000	For W. J. Game Protective Society.
	......do..................	30, 000	30, 000	30, 000	For Mr. Porter.
Virginia	A. Moseley, F. C	100, 000	100, 000	100, 000	Col. M. McDonald, Lexington, via Lynchburg.
Wisconsin	N. K. Fairbank	300, 000	150, 000	200, 000	Geneva Lake.
	C. F. Reed	20, 000	20, 000	20, 000	Reedsburg, Sauk Co.
	William Welch, F. C ...	175, 000	175, 000	100, 000	Madison Fish Hatchery.
Utah	A. P. Rockwood, F. C ...	150, 000	150, 000	100, 000	Great Salt Lake City.
North Carolina	L. L. Polk, F. C..........	500, 000	500, 000	250, 000	Raleigh.
Prussia	Government..............	50, 000	50, 000	50, 000	Minister of agriculture.
Germany	Mr. von Behr	50, 000	50, 000	50, 000	Schmaldow and Greifswald.
Netherlands	C. B. Bottemane.........	250, 000	100, 000	100, 000	Royal Zoological Garden, Amsterdam.
England	Frank Buckland	50, 000	50, 000	50, 000	England.

Table of distribution of salmon eggs, &c.—Continued.

State or country.	Consignee.	No. asked.	No. assigned.	No. forwarded.	Destination.
France		50,000	50,000	50,000	Société d'Acclimatation.
Canada	Minister of Marine and Fisheries.	500,000	500,000	150,000	S. Wilmot, Newcastle, Ontario.
Australia	Sir Saml. Wilson, prest.	50,000	50,000	50,000	
New Zealand	Colonial Secretary, Wellington.	500,000	500,000	500,000	Care J. C. Frisby, care Cross & Co., San Francisco: Auckland, 100,000. Napier, 50,000. Nelson, 50,000. Greymouth, 50,000. Wellington, 50,000. Canterbury, 50,000. Dunedin, 50,000. Southland, 100,000.
Oregon		300,000	300,000	300,000	Columbia River.
California	Sportsman's Club	250,000	250,000	250,000	Lake Merced.
	California Fish Commission.	2,000,000	2,000,000	2,000,000	Tributaries of Sacramento River.
France	Baron de Harber	10,000	8,000	8,000	France.
	Total distributed			6,983,000	

XIII.—ACCOUNT OF TRIP TO EUROPE WITH EGGS OF THE QUINNAT SALMON.

By Fred Mather.

Prof. S. F. Baird,

United States Commissioner Fish and Fisheries:

On the receipt of your request to accompany a large lot of salmon eggs to Germany and other parts of Europe, I considered it necessary to devise some means for repacking them in New York after their long journey from California. I decided as the best method a box with trays so arranged as to allow frequent inspection, and containing an ice-chamber above them whereby the temperature could be regulated and moisture supplied by the constant dripping from the ice. As there were to be 200,000 eggs for England, France, and Germany, with a possible addition of 100,000 more for the Netherlands, which were to come in packages of 25,000, I had eight of the boxes made. Each of these contained at its top an ice-chamber one foot high with a perforated bottom, and beneath this ten frames fourteen inches square, with bottoms of Canton flannel.

It had not been decided whether the shipment for the Netherlands would accompany the others or be sent by steamer direct to Rotterdam; therefore no provision was made for them, as there would be time enough to provide the boxes after their arrival.

From experience in unpacking eggs from California, I deemed it absolutely necessary to have them repacked, for, though the moss-packing is as good as any for the time required to reach the Eastern States from California if immediately unpacked, my experience indicated that it would not be likely to answer for a much longer time, as the following instances will show.

In the fall of 1875 I was in the employ of the Virginia Fish Commission, who were then building two hatching-houses, one at Blacksburg and the other at Lexington, neither of which were finished on the arrival of the eggs. Both lots of eggs were kept in cool places with ice plentifully supplied; those at Lexington were opened and put in the troughs five days after arrival and were in very good order. All the dead eggs had started a fungoid growth, and in a few cases had attached others to them, but there were not many that were apparently injured by the fungus. All fish culturists are aware that some eggs will die out of the very best lot, whether packed and transported by rail or placed in a trough under the most favorable circumstances, and these dead eggs will grow fungus in a long or short time, depending upon the temperature. Persons who obtain a number of eggs and claim to have hatched an equal number of fish from them, unless the embryo is advanced within a few days of hatching, state what those familiar with

the subject know to be highly improbable, and it is no reflection on any mode of packing to find, after a journey of ten or twelve days, that 4 or 5 per cent. are dead. The fact that they are surrounded by 95 per cent. of good eggs is sufficient to show that the fault is in the egg, as far beyond the power of man to help as the cause is beyond his knowledge.

The eggs at Blacksburg were kept eleven days after arrival, and when opened each dead egg had, by its fungoid connection, become the nucleus of a ring of eggs killed by it, each of which in turn was throwing out the deadly filaments on all sides. One egg can thus be surrounded by six. Outside this ring the eggs were in a good state, but the original egg had decayed, and was so firmly attached to the netting above and below it that in opening it was torn in two parts. The lower layer in each crate was the worst, and in one box this was almost entirely spoiled and *warm*, thus showing that the heat from below was not so well absorbed by the ice on account of the intervening packing.

My next experience was in New York City, in 1876, where it was nearly the same. Twenty thousand eggs arrived six days before the carpenters had completed their work, and were iced in the cellar; on opening them, October 11, 12 per cent. were dead, with the ring and decayed nucleus, as before; the remainder, however, were good, and I find by my notes that the first fish hatched October 16, and all were out on the 26th, or fifteen days after placing them in the troughs. Another lot of 40,000 arriving on the 18th, and opened immediately, had a trifle less than 4 per cent. dead, and not a trace of fungus, the dead ones looking as clean as possible. This I call excellent condition. Having these things in mind, and knowing that the ship would leave New York on October 13, and was due at Bremen on the 26th, the date on which a former lot were all hatched, I saw the necessity also of keeping the temperature down to prevent hatching on the passage, as well as to see that no fungus was allowed to germinate.

On the 7th of October, 1877, the refrigerator car from California arrived at Chicago loaded with salmon eggs, and was received by Prof. James W. Milner, deputy commissioner on fish and fisheries, who delivered to me the following lots of eggs: Two crates, 50,000 eggs, for England, care of F. Buckland, London; two crates, 50,000 eggs, for France, care of Societie d'Acclimatation, Paris; two crates, 50,000 eggs, for Germany, care of Herr von Béhr, Deutsche Fischerei Verein; two crates, 50,000 eggs, for Germany, care of M. Friedenthal, minister of agriculture, Prussia; four crates, 100,000 eggs, for Holland, care of C. B. Bottemanne, royal zoological garden, Amsterdam. As they would arrive in New York on the morning of the 9th, and the ship did not sail until the afternoon of the 13th, it was thought advisable to take them to my own house in Newark, N. J., ten miles from New York, where there was a very cool cellar, and no danger of interference by curious people, nor expense of storage.

After getting all ready and opening and repacking one of the boxes for Germany, the contents of which were in splendid condition, I received a

telegram from you that Mr. Stone protested against their being opened, giving as a reason that it would hasten their hatching, and stating that they would go much better without repacking. This was so directly contrary to all my experience that my first impulse was not to go with them; but, on more mature thought, it appeared that by this order the responsibility of their journey was, without option on my part, shifted from myself to Mr. Stone. The best of care was given all of them, and I profited by my experience with those unopened, while also seeing how my own box worked, and having the advantage of not having all the eggs in one basket.

The ship was the "Mosel," of the North German Lloyd, Captain Neinaber, with whom I sailed three years before on the shad expedition in the "Donau," and to whom I am indebted for many favors. Two tons of ice were bought and placed in the ice-room of the ship situated in the lower hold in the extreme forward end, where the "provision steward" keeps his supplies of meats, ice, &c. The crates were placed in the forward hatchway on the main (not upper) deck, in exactly the same place in the same ship as were the shad eggs of Messrs. Welsher and Green in the summer of 1875. The crates were merely an outside frame to hold the fern leaves that enclosed the box of eggs within; they were wedged fast by the ship's carpenter to prevent shifting in a heavy sea, and were kept covered with a large piece of ice all the time, renewed night and morning. The small pieces were removed to the top of my refrigerator box.

Professor Milner had suggested packing the entire lot in ice, surrounded by a load of straw, of which I thought most favorably, but found that, though fish culturists might propose, owners and insurance men would have the final disposition of combustibles, and so that project was dropped, as the officers of the ship objected to it.

The following is a record of temperature within the box of trays in which I had repacked 25,000 eggs. On opening the crate 206 eggs were dead of the 25,000, and after packing I found the temperature next day to be 46° in the top tray and 50° in the bottom, while the air in the cellar was 62°. Ship sailed at 2 p. m. 13th; no record of temperature.

Date.	Air in hatchway.	Top of box.	Near bottom of box.	Remarks.
	°	°	°	
Oct. 14	56	41	48	No eggs on top tray; poured a gallon of ice-water on it.
15	54	42	50	Puzzled about the difference at top and bottom; shifted the trays.
16	54	43	50	Think frames too snug; cut grooves to let heat go up.
17	54	42	52	Put small piece of ice in corner of each tray.
18	70	43	60	Heavy sea; hatchway closed all night; put small ice in ferns of crates.
19	74	48	60	Hatch still closed; cut notches on top of frames to equalize temperature.
20	70	44	60	Raised the screens and put ice below; good result.
21	72	42	48	Hatch closed yet; temperature in box more even.
22	68	42	46	Hatch open; one fish hatched; getting scared.
23	65	42	46	Hatch open.
24	65	43	46	Hatch open; delivered two crates for France at Southampton to Lloyd's agent.
25	70	40	44	Hatch closed; rainy.
26	72	40	43	Hatch closed; rainy; arrived at Bremerhaven.

All consignees were telegraphed from New York of the date of the expected arrival of the ship, and the instructions were not to deliver unless called for. Through some mistake, as I have since learned, Mr. Buckland's agent arrived an hour after the ship had left, consequently the quota for England was taken to Germany and added to the lot for Herr Von Béhr as per previous orders.

At Bremerhaven the eggs were met by Dr. O. Finsch, curator of the Bremen Museum, on behalf of the Deutsche Fischerei Verein; Director Haack of the Imperial Fischerei at Hüningen, Mr. Heck of the Amsterdam Zoological Gardens, and Mr. Schreiber of Hameln on the Weser, who took charge of their respective packages. By request I went with Director Haack to Hüningen, whither my own box was destined.

At Bremerhaven, when the crates were inverted, some decayed matter was seen on one of them, which created an alarm, and several boxes were opened. Of the lot for Amsterdam one box was quite warm, many fish were hatched, but enough appeared good in it to warrant Mr. Heck in taking them home. Mr. Schreiber reported his two boxes better, but I did not see them opened.

Director Haack and self went to Hotel d'Europe with the two English crates, his own, and my box; found the two former entirely spoiled, hot and steaming like a manure heap; thermometer showed 80° in the packing. From his remaining crate we took 8,000 apparently good and put them on a tray in my box.

It is worthy of note that these apparently good ones were in all cases in the corners of the boxes, where the density of the packing kept the heat of the decaying central mass from them. The following shows the mortality in my box:

Oct. 16............	60 dead five days after repacking.
19............	42 dead eight days after repacking.
22............	37 dead eleven days after repacking.
26............	11 dead fifteen days after repacking.
29............	40 dead when put in troughs at Hüningen.
	190
In original package	206
	396 lost in 25,000 from California to Germany.

Half of this lot were sent to the private fishery of Oberburgomeister Carl Schuster, at Freiburg, two hours' ride by rail, where I saw them a week afterward in most beautiful condition, just beginning to hatch.

It is evident that the mode of packing in moss so tightly, while excellent to keep out external heat, is equally effectual in keeping in that which is generated internally, or, as is commonly said, in excluding the cold; and the decaying eggs caused the thermometer to record 80°, while the air outside was not above 50°. Again, the record above shows that of ten frames lying close upon each other, while the top one was 42° those near the bottom were 4 to 6 degrees warmer. This confirms the

result of some experiments made formerly, that *a living fish-egg evolves heat* as a fish does; whether by the friction of circulation, consumption of oxygen, or otherwise, is not to the point here, but from the experiments referred to, and the fact that after getting the eggs in the center of the box as cold as those next the ice, and though completely surrounded by others equally cold they would not remain so, it does appear that such is the case.

Had it been possible to have divested the boxes of the outside ferns and crate, and then packed the boxes in the ice-room, there is no doubt but what the decay of the dead eggs might have been retarded some, and so have preserved the others from the heat; but the ice-room is used for meat, fish, and vegetables, and unless the boxes were at the bottom they might be damaged by overhauling, and should I have to do it all over would use such a box as the one described with a slight modification.

In Germany the question was frequently asked, "When you felt sure that you were right, why didn't you violate orders and repack them all?" to which I could only reply by saying that I did not *know* that the box would be successful; it only *appeared* to be the best, and if a man violates his orders and is victorious he is forgiven, but if he fails he is branded as a self-willed, obstinate fellow.

Returning by way of Berlin, through the kindness of Herr von Béhr Schmoldow, I met the Fischerei Verein, several members of which are in the German Parliament; in fact, most public men in that country take an interest in fish culture, and that it is in high favor may be known by one of the titles of the Crown Prince, which is "Protector of Fisheries."

This lot of eggs was shipped from Sacramento October 2, and some were opened on the 26th; how long they had been packed before delivery to the express company I do not know.

I am aware that in a previous year a successful shipment had somehow been made to New Zealand, and now while writing this I have received a letter stating that a shipment made this season to that country arrived in good order after an ocean voyage of eight weeks; but it does not state how carried, nor at what temperature. My own experience leads me to believe that a crate of eggs packed in California will not keep in good state two weeks after arriving at New York, even in a cool cellar with plenty of ice on top of the crate, and certainly not in a hatchway where, after passing the Banks of Newfoundland, the air ranged from 65° to 74°, as shown in the record above.

As previously stated, one-half of the eggs taken to Hüningen were sent to the Freiburg Society for Fish Culture on the 29th, and after remaining four days at the fishery and seeing the first spawn of the season taken from the trout (*Salmo fario*) by the director, I went to inspect the old salmon fishery belonging to Mr. Glazer, of Basil, situated ten miles up the Rhine at the village of Rhinefelden, where an immense

weight suddenly elevates the net when sprung by the person watching, who holds a cord with twenty branches reaching to as many parts of the net, by which he feels a fish strike against any portion of it.

By request of Herr von Béhr, I then went to Freiburg to await the arrival of the Crown Prince at Wiesbaden, to whom I had letters, and who, as I was informed, was desirous of hearing of the progress of fish culture in America, a subject in which he takes great interest; but, on account of some change in his plans, I received a telegram that he would not reach Wiesbaden during my stay there. I had the pleasure of meeting the president of the Fischerei-Verein, Herr von Béhr, on November 5, at Berlin, and on the evening of the 8th met the society, whose members consist of the leading scientists and statesmen of Germany.

After the transaction of their usual course of business I was called upon for an explanation of the methods in use in America for taking spawn, packing and transporting it, the number of eggs obtained in a season from our different fishes, &c., when, after stating all of importance that came to mind and answering a few questions, we adjourned to a dinner composed of the favorite fishes of Germany.

The fish culturists of that country are keenly alive to the progress of the art wherever practiced; and especially to American improvements, of which there are so many, do they look to see what may be of real value.

For the *Coregoni* they have many of the Holton boxes, which are to be tried upon a large scale this season for the first time for stocking Lake Constance and other waters, while for the *Salmonidæ*, exclusive of the genus above named, they use our unpatented trough with wire or glass trays, and Williamson's trough for the greater part of the work, employing the Coste tray only to a very limited extent.

I left Bremen on the 10th of November for England, where my efforts to collect and transport turbot and sole to our waters met with only a partial success. I will leave the remainder of the trip for a special report concerning those fishes.

XIV.—REPORT ON THE COLLECTION AND DISTRIBUTION OF SCHOODIC SALMON EGGS IN 1877-'78.

By Charles G. Atkins.

1.—Preparations.

The collection of eggs of Schoodic Salmon in 1877 was carried on at the same site and substantially with the same fixtures and in the same methods as in former years. A series of pounds built of stakes and fine-meshed nets on the gravelly shallows below the dam at the outlet of Grand Lake sufficed to entrap almost the whole run of breeding fish, and no other means of taking fish were provided. The eggs were brought forward in the old house at the spring, half a mile up a little brook tributary to Grand Lake Stream.

Though the general plan of the fixtures for entrapping and keeping the parent fish was the same as in previous years, considerable improvements were introduced. The "main lead" by which the fish descending the stream approached our enclosures was narrowed to about 20 feet, and brought to resemble a long tunnel flaring at the upper end to about 60 feet, and at the lower end abruptly contracted to 5 or 6 feet at the point of entrance into the first pound. The water was rapid throughout nearly the whole of this main lead, and afforded so good spawning-ground that we were compelled to exercise great vigilance to prevent many fish making their nests there. It was found necessary to drive down, by means of a small seine in the hands of two men, all the fish that lingered on this ground. As they were apt to take the alarm and dart up stream beyond reach on the approach of any one, a net stretched on stakes across the very head of the lead, and weighted with a heavy chain, was so arranged that it could be drawn up from the bottom by means of a line running ashore and held suspended so as to allow fish to pass freely down into the lead. At fixed hours during the night this net was suddenly dropped, and all retreat being thus cut off the reluctant fish were driven down into the enclosures before they had time to lay their eggs. Probably the fish saved in this way amounted to 10 or 20 per cent. of the total catch, the remainder passing down at once and entering the pounds without compulsion.

Another change introduced this year was the entrapping of the fish in a small pound where they could be examined and counted before placing them in the main enclosure. This was a very satisfactory arrangement. The examinations were made at stated times each night, immediately after driving the fish in from the lead, and the record of

these examinations affords us the data not only for a daily summary of the breeding stock of either sex on hand, but also for some generalizations on the movements of the fish as affected by the weather and other phénomena.

The main pound, where the most of the fish were kept, was, as before, very commodious—about 70 feet long and 40 wide, with a maximum depth of about 5 feet. In this many hundred salmon lay quietly together, making, so far as we could observe, no very strenuous exertions to escape, except a few cases. Another pound of equal size was provided for the spawned fish to lie in while awaiting their transfer to the lake. Besides these, the two trap-pounds, and the "main lead," five other enclosures were provided to enable us to properly assort the fish as we were using them; for instance, in one would be placed those that were tried and found unripe; in another those that had yielded their eggs and were waiting to be pressed the second time, which was always done; another would contain surplus males; another, fish notable for any peculiarity which it was desired to observe further. All these enclosures were formed of fine-meshed nets hung on stakes and for the most part held down at the bottom by the weight of chains, which rendered it easy to transfer a whole body of fish from one enclosure to another by lifting the bottom of the net and driving them under.

The only change made at the hatching-house was the complete cleaning out of the brook which afforded an outlet both for the water of the spring and the surface water of the vicinity. This flows for a long distance over flat, low ground, and on two former occasions sudden rains had raised the water until it reached the tops of our hatching-troughs, threatening, but not accomplishing, serious mischief. To avoid a disaster from this source the brook was cleared out, widened, and deepened for a distance of about 140 rods. Even with this improvement, however, the site of the hatching-house is a very unfavorable one. Both spring and brook water can be used, but the brook is a tiny one, and in cold and dry weather shrinks to a very insignificant volume, while the spring issues from the ground at such a slight elevation above the swamp through which it flows that at best we can barely get our troughs high enough to avoid flooding by freshets. There is thus no opportunity of aerating the water by a fall, and the trough must be placed on a level with the floor, an unfavorable position for work. However, no better arrangement could be made. No larger spring could be found in the neighborhood; there was no clean and ample brook; and the water of Grand Lake Stream itself, though probably unsurpassed for such a purpose by any in the world, could not be used on account of certain physical difficulties which I saw no way of surmounting with the means at my disposal.

2.—The fishing.

The main nets were placed in the stream September 17, and at the same time a strong movable net placed across the head of the canal

m the lake to the neighboring tannery. These measures fish practically within control, though some had already wn the stream below our fishing-ground. There were many en about the dam as early as the first week in October, and h they were seen lying in groups above the nets. The first s found October 24, and by the beginning of November a good could be counted on the ground accessible to the fish. The oned fish did not, however, make any attempt at spawning until later.

e first eggs were taken October 31, but few fish were ripe at that , the females taken the following night, 51 in number, affording but ripe specimens. On the 5th of November the work of taking spawn s begun in earnest, and continued almost daily up to the 24th, when at part of the work was brought to a close. From the beginning it was the common practice to examine each morning the fish caught during the night, and take eggs from all that were ready, placing the unripe in the general enclosure, which was overhauled only once a week. At first, and indeed until the middle of November, about half the female fish were unripe when they first came to hand, and up to the very last day there were still some that were not quite ready to yield their eggs. This is in marked contrast to my former experience with the sea-going salmon at Bucksport, where, after the 1st day of November, an unripe fish was rarely found.

As usual the male fish were earlier on the ground. Up to the 6th of November, when, for the first time, the entire stock had been examined, 59 per cent. of the fish were males, while of the entire catch for the season they constituted only 43 per cent. The proportion of males in 1875 was 40 per cent., and in 1876 only 27 per cent. Of the whole number of fish taken all were mature males and females except barely three specimens whose sex was not ascertained, their reproductive organs not being sufficiently developed; these were a little smaller than the gravid females, which they much resembled (being, however, much slenderer), and very likely were simply strays from a large brood in the lake not yet arrived at adult age.

By reference to the tabulated statement of the fishing (Table I) it will be seen that, for the most part, the fish ran much plentier in the early than the late part of the night. This predominance of the evening catch was most marked during the period of the heaviest run of fish, the first ten days of November. During the day their downward movements were almost entirely suspended except on one or two days, especially at the time when at the height of their run, for instance on the 10th of November, when 111 fish came in before 4 p. m.

The influence of the weather was not very marked. So far as our observations go they indicate a slight preference of the fish to run into our enclosures in clear weather rather than cloudy, and without regard to the moon or the force of the winds. Of the five nights when the morn-

ing catch exceeded the evening catch, the record shows that two began with stormy weather, but cleared off before morning; two others were rainy nights nine and ten days after full moon, while the fifth and most notable instance (November 9–10) was on a night partly clear and partly cloudy, succeeding a rainy day, five days after new moon, when, of course, the evening was light and the morning dark. On ordinary pleasant nights the greatest run was commonly in the evening, whatever the phase of the moon. The very best catch (425 fish, November 3 and 4,) was with light northwest wind, and clear sky all night, with no moon. The next best three (of 375, 368, and 362 fish, respectively,) were also on nights with northerly wind, mostly clear. Of the next two (291 and 272 fish, respectively,) one was on a clear evening followed by a cloudy morning, and the other on occasion of a storm which cleared away during the night and gave us a heavy morning catch.

3.—Taking spawn.

In taking spawn the ordinary procedure was about as follows: The fish to be operated upon were brought close in front of the spawning-shed by means of a fine seine, and were then dipped up, two or three at a time, in a dip-net, and passed to the operators in the shed, who, armed with woolen mittens, sat on stools, with ten-quart tin pans before them. The fish that came first to hand, whether male or female, was immediately used, if ready. The males were always ready. If a female, her condition was first judged from her appearance when held up by the tail. If ripe, the mass of spawn would settle down towards the head, distending excessively the anterior part of the abdomen, which was very soft and yielding to the touch, and leaving the posterior part very lank. Such a fish was immediately pressed and the eggs received in the pan. If the fish, when suspended in this way, retained its shape, and its abdomen felt firm to the touch it was pronounced unripe without being subjected to pressure. The eggs of from six to ten females (averaging 1,000 eggs apiece), and the milt of about the same number of males (or less) were pressed into the same pan, and after using each fish the eggs and milt were brought into more complete contact by swaying the pan. Not much regard was paid to the order in which the fish were used. When six to ten thousand eggs were gathered in one pan, it was, after repeated swaying, passed over to be weighed and afterwards watered and rinsed off. There was no fixed rule as to the length of time the milt and eggs should remain in contact. Commonly some of them were in contact half an hour or an hour and others only a few minutes. After rinsing, the eggs were covered with water, the pans being nearly filled, and then placed on shelves to await the complete distention of the shell, after which they were taken to the hatching-house in pails, as soon as convenient. If compelled to stand several hours in the pans they were treated with a change of water. No water was placed in the pans until contact between eggs and milt was supposed to have been secured, but

no special pains was taken to avoid the dripping of water from the fish into the pan while the process of taking the eggs was going on. I have thus minutely described the method pursued in order to explain the occasional reference to the "usual method" in the tabular statement of spawning operations (Table II). Occasional variations of the method were made for experiments' sake, and such variations are noted in the table. Subsequently, as soon as the eggs had reached the proper stage for examination, the date of impregnation of each lot was ascertained by taking 50 to 200 and examining each one critically. This number was, I am convinced, too small for the purpose, and the results obtained and indicated in the table can only be considered as rough approximations to the actual rate of impregnation. The proper estimation of the impregnation of a large lot of eggs, say 100,000, would, I think, require the careful examination of as many as 500 eggs, or, better still, 1,000, taken from different parts of the lot, which, for a large number of such lots, would be quite a task. Such as it was the examination showed the ratio of impregnation to have ranged from 87 to 100 per cent. Probably the true average ratio was not much less than 95 per cent. No advantage is indicated as resulting from the pains taken on several occasions to give the eggs an extra quantity of milt, nor from unusual care in selecting ripe and rejecting unripe fish. I am not, however, willing to accept these indications as conclusive.

It is a matter of some importance to ascertain in what way, if any, the percentage of eggs lost through non-impregnation may be still further reduced, and many experiments were tried, for this as well as other objects, but they need to be supplemented by repetitions another year, and can best be described in a future report.

When we were not too much pressed with work, all the fish were weighed and measured immediately after leaving the hands of the spawn-takers. A summary of the results is given in Table IX. From this it appears that the average length of the males was 16.8 inches (= 43 centimeters); longest, 22 inches (= 56 centimeters); shortest, 14 inches (= 35 centimeters). The males weighed, on the average, 1.8 pounds (= .8 kilogram); the heaviest, 3.7 pounds (= 1.7 kilograms); the lightest, 1.1 pounds (= .5 kilogram). These are the results of the measurement of 235 fish. Of gravid females, 343 were weighed and measured, with the following results: heaviest female, 3.6 pounds (= 1.6 kilograms); lightest, 1.2 pounds (= .5 kilogram); average, 1.9 pounds (= .9 kilogram); length of same females, average, 16.1 inches (= 41 centimeters); longest, 20 inches (= 51 centimeters); shortest, 13 inches (= 33 centimeters).

At the close of the season's work the fish were taken in cars specially arranged for such work, and towed about two miles up the lake, where they were turned loose. Some of the males found their way back to the stream within a few hours of being set at liberty, but the most of them, and nearly all the females, staid in the lake.

4.—Incubation.

The only apparatus in use at the hatching-house for the incubation of eggs was that devised by myself in 1875. As adapted to use in a hatching-trough, it consists of movable frames, each a little more than a foot square and about eight inches deep, and holding each 10 or 11 wire trays so constructed that a horizontal aperture of one-eighth inch extends on all sides (except a small space at each corner) above each tray, thus permitting the passage of a horizontal current of water. The frames are made to fit the troughs pretty closely, and the water was thus compelled to flow through between the trays. The picking was done on a table, to which the frames were removed for the purpose. This form of apparatus is very compact, simple, and easily managed. We had about 20,000 eggs in each frame, occupying a trifle more than a square foot of space in the trough. There were six troughs, each 25 feet long.

5.—Distribution of eggs.

The total number of eggs obtained was, according to the estimates made from day to day, 2,159,000. I think these figures too large by 5 per cent., but as the distribution of the eggs was made on that basis, the estimate is retained. Early in January it was found necessary to begin shipping eggs to other points for hatching, and the last case was sent off February 19. The distribution may be summarized as follows:

Shipped to order of Commissioners of Fisheries of Massachusetts	255, 000
Shipped to order of Commissioners of Fisheries of Connecticut	255, 000
Shipped to order of United States Commissioner of Fish and Fisheries	890, 000
Retained to be hatched for Grand Lake Stream	470, 000
Losses previous to distribution of eggs	289, 000
	2, 159, 000

The number of eggs obtained was far in excess of my expectations. It was twice as great a number as I had expected the hatching-house would ever have to receive. The volume of water flowing through the troughs was, on the 16th November, twenty-two gallons per minute. This would have sufficed, but in December it shrank to the very small volume of five or six gallons per minute. This was due partly to a leak under the dam that was not discovered until several months later, but mainly to a long period of dry, cold weather. The result was a serious injury to a portion of the eggs. There is now no doubt that they were overcrowded. The water appears to have been of good quality, but too warm, and the site of the spring, as already explained, did not admit of the application of any practicable method of aeration. The water afforded an ample supply of air to the eggs that first received it, but be-

fore it reached the lower ends of the troughs it was too far exhausted to sustain and develop the eggs lying there. The volume of water was renewed at a later date, and the eggs that remained to be hatched for the stream did very well, but a very considerable number had been so seriously affected as to unfit them for transportation to distant points. No excessive mortality occurred on the route, most of the packages, even those sent to a great distance, opening in fine shape; but there was a premature hatching immediately after unpacking, followed by a torpid condition and subsequent death of a great many of the fry. One case of eggs (and I think several), which I am confident would have turned out excellently if they had received proper treatment while in transit, were, in spite of legible placards attached to each box warning against heating, left by careless messengers close to hot stoves, and on opening were found to be actually heated through. The loss sustained on the various shipments ranged all the way from 5 to 100 per cent. and averaged about 40 per cent. The details may be learned by comparing Tables III and IV.

Subjoined are eleven tables embodying statements of the work done and results obtained, including certain observations made in 1875 and 1876, and not before reported.

TABLE I.—*Record of fishing at Grand Lake Stream, Maine, October and November, 1877.*

Date.	Weather.	Temperature. Air. 7 a. m.	Temperature. Water. 7 a. m.	Hour.	Schoodic salmon caught. Nightly catch. Males.	Females.	Unknown.	Total.	Nightly summary. Males.	Females.	Unknown.	Total.	Notes.
1877.		F.	F.										
Oct. 22, 23	Still; clear moonlight; 1 day past full moon	31½	46	9 p. m.	7	2	0	9					Caught 2 eels and 1 brook-trout.
				7 a. m.	8	1	0	9					
									15	3	0	18	
23, 24	do	33	47	9 p. m.	11	2	0	13					1 eel; 1 togue.
				7 a. m.	10	1	0	11					
									21	3	0	24	
24, 25	Evening dark; still; light rain; during night, calm, cloudy, and two inches of snow.	31	47	9 p. m.	55	16	0	71					
				7 a. m.	48	15	0	63					1 whitefish; 2 large eels.
									103	31	0	134	
25, 26	Evening dark, wind northeast; very light snow; cleared off cold some time in the night.	24	44	8 p. m.	46	17	0	63					
				7 a. m.	35	8	0	43					7 large eels.
									81	25	0	106	
26, 27	Clear and very fine; wind northwesterly, but very light.	28	44	9 p. m.	29	6	0	35					
				7 a. m.	17	2	0	19					
									46	8	0	54	
27, 28	Clear and fine; almost or quite calm	29	44	9 p. m.	20	8	0	28					
				9 a. m.	18	0	0	18					1 small eel.
									38	8	0	46	
28, 29	Calm and clear in evening; calm and cloudy in morning.	30	44	9 p. m.	31	18	0	49					
				7 a. m.	20	2	0	22					1 togue.
									51	20	0	71	
29, 30	Rain, with southerly wind, till 8 p. m.; clear and fine all the rest of the night with little or no wind.	35½	44½	9 p. m.	26	15	0	41					
				7 a. m.	50	22	0	72					4 eels.
									76	37	0	113	
30, 31	Clear and calm all night	24½	44½	9 p. m.	51	22	0	73					
				7 a. m.	43	28	0	71					
									94	50	0	144	
Oct. 31 } Nov. 1 }	Light rain with northeast wind all night	34½	45	8 p. m.	40	17	0	57					
				11½ p. m.	16	10	0	26					7 eels.
				7 a. m.	46	27	0	73					
									102	54	0	156	

Nov. 1, 2	Cloudy, with little or no wind	31	44	7½ p. m.	30	14	0	44					
				11½ p. m.	35	22	0	57					
				7 a. m.	38	27	0	65	103	63	0	166	1 togue; 1 eel.
2, 3	Heavy rain with southerly wind until 11 p. m.; continued cloudy several hours, but cleared away with westerly wind before morning.	41	45	8½ p. m.	35	33	0	68					
				12 midn't.	49	37	0	86					
				7 a. m.	73	45	0	118	157	115	0	272	1 eel.
3, 4	Clear with light northwest wind all night	31	43	8½ p. m.	75	141	0	216					
				12 midn't.	49	73	0	122					
				7 a. m.	55	32	0	87	179	246	0	425	
4, 5	Cold and clear with some northerly wind: new moon	28	42½	4 p. m.	19	19	0	38					
				8 p. m.	92	96	0	188					
				12 midn't.	35	41	0	76					
				7 a. m.	32	28	0	60	178	184	0	362	
5, 6	Wind southerly in evening, changing to northerly in morning; rain light in evening, heavy after 12.	39	43	11 p. m. / 7 a. m.	74	99	0	173	74	99	0	173	
6, 7	After a day of very strong wind follows a clear cold night, with north wind gradually dying out.	19½	40	9 p. m.	100	178	0	278					
				12 midn't.	22	45	0	67					
				7 a. m.	14	16	0	30	136	239	0	375	
7, 8	Clear	23½	40½	9 p. m.	19	61	0	80					
				12 midn't.	7	23	0	30					
				7 a. m.	10	22	0	32	36	106	0	142	
8, 9	Wind southerly, strong; evening cloudy; began to rain at 11 p. m., and rained hard till morning.	54½	44	8 p. m.	10	42	0	52					
				12 midn't.	9	33	0	42					
				7 a. m.	5	27	0	32	24	102	0	126	1 eel; 1 brook-trout.
9, 10	After a rainy day, with southwest wind, wind changed to northerly and blew strong all night; partly clear, partly cloudy.	28½	42	4 p. m.	10	32	0	42					
				8 p. m.	7	72	0	79					
				12 midn't.	8	83	0	91					
				7 a. m.	32	124	0	156	57	311	0	368	3 eels.
10, 11	Nearly calm all night; clear in evening; clouded up after midnight.	24	41½	4 p. m.	18	93	0	111					
				7 p. m.	19	58	0	77					
				9 p. m.	9	38	0	47					
				12 midn't.	4	25	0	29					
				7 a. m.	5	22	0	27	55	236	0	291	
11, 12	Clear and calm in evening; clouded up and wind sprang up at 1 o'clock, blowing from north.	25	41	8½ p. m.	31	71	0	102					
				12 midn't.	8	32	0	40					
				7 a. m.	15	26	0	41	54	129	0	183	
12, 13	Wind northerly all night, mostly strong; mostly clear.	29	39		32	63	0	95	32	63	0	95	2 whitefish; 1 male, 1 female.
13, 14	Light northerly wind; partly clear	20	38		22	41	1	64	22	41	1	64	2 eels, female.

TABLE L—*Record of fishing at Grand Lake Stream, Maine, October and November, 1877*—Continued.

Date.	Weather.	Temperature. Air. 7 a. m.	Temperature. Water. 7 a. m.	Hour.	Schoodic salmon caught. Nightly catch. Males.	Nightly catch. Females.	Nightly catch. Unknown.	Nightly catch. Total.	Nightly summary. Males.	Nightly summary. Females.	Nightly summary. Unknown.	Nightly summary. Total.	Notes.
1877.		F.	F.										
Nov. 14, 15	Clear, calm, warm	30	40	8 p. m.	9	26	0	35					
				12 midn't	2	22	0	24					
				7 a. m.	8	3	0	11	19	51	0	70	
15, 16	Cloudy, followed by rain; wind southeast; very light.	46	41	8 p. m.	3	17	0	20					
				12 midn't	0	7	1	8					
				7 a. m.	3	3	0	6	6	27	1	34	
16, 17	Cloudy in evening, with southerly wind; at 10½ changed to clear and calm.	38½	41	7½ p. m.	3	14	0	17					1 gravid female brook-trout.
				12 midn't	6	11	0	17					
				7 a. m.	5	8	0	13	14	33	0	47	
17, 18	Cloudy, with some sleet and snow	31	40½	7 p. m.	2	11	0	13					
				12 midn't	1	6	0	7	3	17	0	20	
18, 19		32	40	7 p. m.	?	23	1	24					
				12 midn't	?	1	0	1					
				7 a. m.	?	15	0	15	?	39	1	40	
19, 20		26	37		?	14	0	14	?	14	0	14	
20, 21	Full moon	22	36		?	10	0	10	?	10	0	10	
21, 24					?	8	0	8	?	8	0	8	
									1,776	2,372	3	4,151	

TABLE II.—*Record of spawning operations, Grand Lake Stream, 1877.*

Date.	Remarks.	Fish at first handling.							Females spawned.		Females.		Eggs.				Remarks.
		Total.	Males.	Females.				Barren.	First handling.	Afterward.	Total spawned.	Respawned.	Weight.*	Number.	Lots.	Impregnation.†	
				Unripe.	Ripe.	Spent.	Total.										
1877.													*Lbs. oz.*			*Perct.*	
Oct. 31	From main lead (part)	3	1	0	2	0	2	0	2	......	2	......	‡1 0	2,000	1	100	Treatment as usual.
Nov. 1	All of the females and part of the males that came and were driven in last night.	73	22	39	12	0	51	0	12	......	12	......	5 6	11,000	2	93	Treatment as usual, except a much heavier milting.
5	Fish handled first on Nov. 1	......	......	......	......	......	......	......	......	28	28	12	10 9				Treatment as usual, except great pains to handle in small lots and secure contact between milt and spawn.
5	Fish taken last midnight	76	34	16	26	0	42	....	26	......	26	....					
5	Fish taken this morning	60	32	13	15	0	28	....	15	......	15	....	136 15	328,000	4	97	
5	Main pound, in part	1,379	830	243	304	2	549	....	304	......	304	....					
6	Fish taken last night	173	74	50	46	3	99	....	46	......	46	......	13 11	39,750	6	89	
6	Main pound, finishing it	429	290	54	85	....	139	....	85	......	85	......	32 14	74,250			
	Summary to date	2,193	1,283	415	490	5	910	0	490	28	518	12	200 7	455,000	......	......	518 females yield total of 508,500§ eggs.
7	Rehandling of all spawned before.	......	......	......	......	......	......	......	......	......	......	506	24 8	53,500	7	90	
7	Fish taken last night	375	136	114	123	2	239	0	123	......	123	......	51 $1\frac{1}{2}$	113,000	8	94	
8	......do	142	36	67	39	0	106	0	39	......	39	......	15 0	33,000	9	93	Apparent greater number of unripe fish owing to more rigid rejection of all that admitted of doubt—such not generally pressed at all. Milting not so heavy as usual.
9	......do	132	24	66	41	1	108	0	41	......	41	......	15 9	34,500	10	98	
	Summary to date	2,842	1,479	662	693	8	1,363	0	693	28	721	......	306 9	689,000			

* The eggs were weighed in the spawn-pans just before applying water, and therefore included not only the liquid that came with them from the mother-fish, but also what milt had been used to impregnate them.

† To obtain data to estimate the ratio of impregnation, a sample, numbering from 50 to 200, was taken from each lot, and each egg of the sample carefully examined. I am convinced, however, that the number examined was too small for the purpose. The percentages stated must therefore not be regarded as very accurate, but as only indicating the ratio in a general way.

‡ Estimated.

§ I am inclined to think that the eggs taken this season (and other seasons, as well) were overestimated 5 per cent., perhaps more.

TABLE II.—*Record of spawning operations, Grand Lake Stream, 1877*—Continued.

Date.	Remarks.	Fish at first handling.							Females spawned.		Females.		Eggs.				Remarks.
		Total.	Males.	Females.				Barren.	First handling.	Afterward.	Total spawned.	Respawned.	Weight.*	Number.	Lots.	Impregnation.†	
				Unripe.	Ripe.	Spent.	Total.										
1877.													*Lbs. oz.*			*Perct.*	
Nov. 10	Respawning											203	11 11	23,500	11	89	721 females yield 712,500‡ eggs.
10	Fish taken last night	368	57	171	134	6	311	0	134		134		57 8				
10	Fish taken to-day (8 a. m. till 4 p. m.).	111	18	62	29	2	93	0	29		29		12 11	166,000	12	91	
10	Fish caught at 7 p. m	77	19	36	16	6	58	0	16		16		6 15				
	Summary to date	3,398	1,573	931	872	22	1,825	0	872	28	900	721	395 6	878,500			
12	Respawning											179	11 11	21,500	13	98	900 females yield total of 900,000‡ eggs.
12	Fish taken this morning	41	15	11	11	4	26	0	11		11		4 7	66,000	14	96	
12	Fish from main pound									64	64		27 13				
13	Fish taken last night and this morning.	95	32	27	31	5	63	0	31		31		12 11				
13	Fish handled before from main pound.									418	418		170 8	482,000	15	95	
13	Fish from main pound put in on 11th, and now for first time handled.	245	57	79	80	29	188		80		80		34 15				
14	Fish taken during last twenty-four hours, ending 7 a. m.	64	22	16	18	7	41	1	18		18		7 6	17,000	16	94	
14	Finish of main pound									2	2		13				
	Summary to date	3,843	1,699	1,064	1,012	67	2,143	1	1,012	512	1,524	900	665 10	1,465,000			
15	Respawning											624	31 1	59,000	17	97	1,524 females yield 1,534,000‡ eggs.
15	Fish taken last night	70	19	17	27	7	51	0	27		27		11 2	23,000	18	96	
16	do	34	6	12	12	3	27	1	12		12		4 13	11,500	19	90	
													0 6	500	53		Milted with milt from living whitefish unsuccessfully.
17	do	60	25	16	17	2	35	0	17		17		4 11	11,000	20	88	Experiments.
													2 0		61–101		
19	Respawning											56	4 6	9,000	21	96	

19	Fish taken last night			2	3		6	0	3		3		9	12				A large additional number of males were taken, but all supposed to have been handled before.
										21	21				380, 500	22	94	
19	From main pound									401	401		136	4				
20	From main pound, finishing it									149	149		63	1				
20	Fish taken last night	14		4	5	5	14	1	5		5				137, 000	23	88	
										10	10							
21	Respawning											574	21	0	39, 500	24	95	
															2, 000	102–125		Experiments.
21	Last night's fish	10		1	7	2	10	0	7		7		2	8	5, 500	25	94	
24	From various sources	8		1	0	7	8	0						15	15, 500	26	87	
24	Fish from main pound									16	16		6	9				
	Total	4, 039	1, 749	1, 117	1, 083	93	2, 293	3	1, 083	1, 109	2, 192	2, 154	964	2	‡2, 159, 000			

* The eggs were weighed in the spawn-pans just before applying water, and therefore included not only the liquid that came with them from the mother-fish, but also what milt had been used to impregnate them.

† To obtain data to estimate the ratio of impregnation, a sample, numbering from 50 to 200, was taken from each lot, and each egg of the sample carefully examined. I am convinced, however, that the number examined was too small for the purpose. The percentages stated must therefore not be regarded as very accurate, but as only indicating the ratio in a general way.

‡ I am inclined to think that the eggs taken this season (and other seasons as well) were overestimated 5 per cent., perhaps more.

TABLE III.—*Record of shipment of salmon-spawn from Grand Lake Stream, January and February, 1878.*

Date.	Consignee.	Address.	Number of cases.	For what State.	Number of eggs— Belonging to State.	Donated by United States.	Total.
1878.							
Jan. 2	J. B. Kirby & Son	New Haven, Conn	3	Connecticut	150,000		150,000
3	E. A. Brackett	Winchester, Mass	2	Massachusetts	115,000		115,000
8	G. H. Jerome	Pokagon, Mich	1	Michigan		50,000	50,000
8	T. B. Ferguson	Baltimore, Md	1	Maryland		50,000	50,000
8	F. N. Clark	Northville, Mich	1	Michigan		5,000	5,000
10	E. A. Brackett	Winchester, Mass	1	Massachusetts	20,000		20,000
				New Hampshire		20,000	20,000
10	B. B. Redding	San Francisco, Cal	2	California		50,000	50,000
11	R. O. Sweeny	Saint Paul, Minn	1	Minnesota		60,000	60,000
14	B. F. Shaw	Anamosa, Iowa	1	Iowa		55,000	55,000
14	William Griffith	Louisville, Ky	1	Kentucky		20,000	20,000
15	Mrs. J. H. Slack	Bloomsbury, N. J	2	New Jersey		50,000	50,000
16	Henry Fairbanks	Saint Johnsbury, Vt	1	Vermont		25,000	25,000
17	E. A. Brackett	Winchester, Mass	2	Massachusetts	95,000	20,000	115,000
18	J. Coolidge Coffin	Pembroke, Me	1	Maine		40,000	40,000
18	F. F. Innis	Houlton, Me	1	....do		20,000	20,000
21	George H. Jerome	Pokagon, Mich	1	Indiana		25,000	25,000
21	W. A. Pratt	Elgin, Ill	1	Illinois		10,000	10,000
21	L. C. Starkel	Belleville, Ill	1	....do		10,000	10,000
				Missouri		10,000	10,000
21	N. K. Fairbank	Chicago, Ill	1	Wisconsin		10,000	10,000
21	M. McDonald	Lexington, Va	1	Virginia		12,500	12,500
21	M. G. Ellzey	Blacksburg, Va	1	....do		12,500	12,500
22	J. B. Thompson	New Hope, Pa	1	Pennsylvania		10,000	10,000
22	New York State Hatching House	Caledonia, N. Y	1	New York		25,000	25,000
22	E. D. Potter	Toledo, Ohio	1	Ohio		25,000	25,000
22	T. B. Ferguson	Baltimore, Md	1	North Carolina		40,000	40,000
22	L. R. Lock	Pottersville, N. Y	1	New York		25,000	25,000
28	T. B. Ferguson	Baltimore, Md	1	Georgia		25,000	25,000
				North Carolina		10,000	10,000
28	James Duffy	Marietta, Pa	1	Pennsylvania		37,500	37,500
28	Seth Weeks	Corry, Pa	1	....do		12,500	12,500
28	C. S. White	Romney, W. Va	1	West Virginia		10,000	10,000
29	A. A. Reed	Providence, R. I	1	Rhode Island		10,000	10,000

Feb. 11	Fred. Mather	Newark, N. J	1	Germany		25,000	25,000
13	......do	......do	1	France		10,000	10,000
13	E. A. Brackett	Winchester, Mass	1	Massachusetts	25,000		25,000
13	S. H. Kirby	New Haven, Conn	1	Connecticut	70,000		70,000
18	......do	......do	1	....do	35,000	20,000	55,000
18	William Griffith	Louisville, Ky	1	Kentucky		10,000	10,000
18	E. D. Patten	Toledo, Ohio	1	Ohio		10,000	10,000
18	New York State Hatching House	Caledonia, N. Y	1	New York		10,000	10,000
18	A. E. Neill	Grand Lake Stream, Maine		Maine		10,000	10,000
19	Alfred Swazey	Bucksport, Me	1	....do		10,000	10,000
	Total		46		510,000	890,000	1,400,000

TABLE IV.—*Statement of the distribution of young Schoodic Salmon*, 1878.

State.	Place of hatching.	In charge of hatching.	No. of fish sent out.	Waters stocked.	Tributary to what other water.	Locality.	No. of fish set free.
California	San Leandro	J. G. Woodbury	39,950	Donner Lake		Nevada and Placer Counties	10,000
				Sereno Lake			
				Felch's Lake		San Mateo County	5,000
				Espinoza Lake		Monterey County	5,000
				Woodward's Aquarium		San Francisco	500
				Tulare Lake		Tulare County	15,000
				Lake Chabot		Alameda County	2,500
				Arroyo Laguna		do	700
				Laguna Honda		San Francisco County	1,000
				Echo Lake		El Dorado County	250
Connecticut	North Branford	S. H. Kirby	175,000	Twin Lakes		Salisbury	10,000
				Spectacle Ponds		Kent	10,000
				Square and Green Ponds		Sherman	10,000
				Gardiner's Lake		Salem	10,000
				Hog Lake		Lyme	10,000
				Snipsic Lake		Rockville	10,000
				Hampton Pond		East Hampton	10,000
				Bantam Lake		Litchfield	10,000
				Wauramaug Pond		South Coventry	10,000
				Long Lake		West Winsted	10,000
				Stafford Springs Reservoir			10,000
				Brooks	Connecticut River	Near Thompsonville	10,000
				Rogers's Lake			15,000
				Brooks	Thames River	Near Willimantic	15,000
				Saltonstall Lake			10,000
				Valley Pond		Woodbridge	5,000
Illinois	Elgin	W. A. Pratt	4,400	Twin Lakes		Richmond, McHenry County	4,000
				—— Pond		Elgin	200
				—— Pond		Trenton	200
Indiana	Pokagon, Mich	G. H. Jerome	25,000				
Iowa	Anamosa	W. A. Pratt	20,000	Silver Creek		De Witt, Clinton County	3,000
				Clear Lake		Clear Lake, Cerro Gordo County	3,000
				Cedar River		Cedar Rapids, Linn County	3,000
				Iowa River		Tama City, Tama County	3,000
				Des Moines River		Boone, Boone County	3,000
				Hatching ponds		Anamosa	5,000
Kentucky	Louisville	William Griffith	5,500	Asher's Creek	Salt River	Near Taylorsville, Spencer County	1,000
				Pitman Creek	Cumberland River	Somerset, Pulaski County	1,000
				—— Pond		Smith's Grove, Warren County	500
				—— Pond		Versailles, Woodford County	500
				Nolin Creek	Green River	Elizabethtown, Hardin County	1,000
				Glasser's Lakes		Covington, Boone County	500
				Kinniconick Creek	Ohio River	Vanceburg, Lewis County	1,000

Maine	Pembroke	J. C. Coffin	35, 211	Moosehorn Waters	Penmaquan River	Charlotte	15, 000
				Sprague's Pond	....do	......do	5, 000
				Cathance Lake	Denny's River	Cooper	10, 000
				Crocker's Lake	Penmaquan River	Charlotte	5, 000
	Houlton	F. F. Innis	5, 000	Drew's Lake	Meduxnekeag River	Aroostook County	3, 000
				Limerick Lake	....do	..... do	2, 000
	Bucksport	A. Swazey	9, 500	Cold Spring Pond	Penobscot River	Enfield	5, 000
				Newport Pond	Kennebec River	Newport	4, 500
				Grand Lake	Saint Croix River	Washington County	437, 000
	Grand Lake Stream	Wm. H. Munson	437, 000	Keene's Lake	....do	Calais	10, 000
	....do	....do	10, 000	——— Pond	Potomac River	Waverton	700
Maryland	Baltimore	T. B. Ferguson	40, 781	——— Stream	Patuxent River	Spencerville	500
				Crystal Iron Springs	Monocacy River	Emmittsburg	2, 500
				——— Pond	Patuxent River	Forestville	1, 000
				——— Pond	Patapsco River	Hood's Mills	3, 500
				——— Pond	Gwynn's Falls	Reisterstown	250
				Gunpowder River		Cockeysville	23, 000
				Cascade Branch	Patapsco River	Elk Ridge	500
				——— Pond	....do	Westminster	1, 000
				——— Pond		Deer Park	7, 831
				Ponds		South Weymouth	4, 000
Massachusetts	Winchester	E. A. Brackett	223, 000	....do		Wellfleet	8, 000
				....do		Middleborough	30, 000
				....do		Natick	4, 000
				....do		Winchendon	8, 000
				....do		Winchester	8, 000
				....do		Milton	7, 000
				....do		Harvard	4, 000
				....do		Lynn	3, 000
				....do		Wenham	4, 000
				....do		North Rochester	5, 000
				....do		North Andover	(?)
				....do		East Bridgewater	4, 000
				....do		West Scituate	4, 000
				....do		Stockbridge	20, 000
				....do		Stoneham	8, 000
				....do		Lawrence	8, 000
				....do		Hubbardston	5, 000
				....do		North Sandwich	4, 000
				....do		Ashburnham	8, 000
				....do		Fall River	5, 000
				....do		Salem	10, 000
				....do		Holyoke	7, 000
				....do		Pittsfield	16, 000
				....do		Braintree	8, 000
				....do		Wakefield	6, 000
				....do		Greenwood	8, 000
				....do		Waltham	4, 000
				Halfway Pond		Plymouth	(?)

TABLE IV.—*Statement of the distribution of young Schoodic Salmon*, 1878—Continued.

State.	Place of hatching.	In charge of hatching.	No. of fish sent out.	Waters stocked.	Tributary to what other water.	Locality.	No. of fish set free.
Michigan	Pokagon	G. H. Jerome	26,000	Tinkham Lake		Niles, Berrien County	5,000
				Metcalf Lake		Calhoun County	4,000
				Goguac Lake		Battle Creek, Calhoun County	4,000
				Crooked Lake		Surrey, Clare County	4,500
				Roney Lake		Clare County	1,500
				Whitefish Lake		Pierson, Montcalm County	7,060
	Northville	F. N. Clark	4,500	Rough River		Northville	4,500
Minnesota	Red Wing	S. S. Watkins	8,000	McCann's Lake		Ramsey County	3,500
				Rice Pond		do	3,500
				Northfield Lake		Rice County	1,000
New Hampshire	Winchester, Mass	E. A. Brackett	20,000	Silver Lake		Madison	5,000
				Merrymeeting Lake		New Durham	5,000
				Sunapee Lake			6,000
				Stocker's Pond		Grantham	4,000
New Jersey	Bloomsbury	Mrs. J. H. Slack	39,000	Strubel's Lake		Andover, Sussex County	39,000
New York	Caledonia	Seth Green	2,000	Spring Creek		Caledonia, Livingston County	2,000
North Carolina	Baltimore, Md	T. B. Ferguson	15,500	John's River	Catawba River	Near Morganton, Burke County	1,000
				Linville River	do	Near same place	4,400
				——— Ponds	do	Near Charlotte, Mecklenburg County	500
				——— Ponds	Cape Fear River	Near Greensborough, Guilford County	2,000
				——— Ponds	Catawba River	Near Morganton	600
				——— Ponds	Yadkin River	Near Salisbury, Rowan County	1,000
				Moyo River	Dan River	Rockingham County	3,000
				Dan River	Roanoke River	Near Danbury, Stokes County	3,000
Ohio	Toledo	E. D. Potter	12,000	Maumee River	Lake Erie	Twelve miles above Toledo	12,000
Pennsylvania	New Hope	J. B. Thompson	9,444	Aquetong Lake	Delaware River	Solesbury, Bucks County	9,444
	Marietta	J. P. Creveling	29,050	Schuylkill River	do	Schuylkill County	2,300
				Jones's Lake		Wayne County	5,000
				Beaver Lake		Luzerne County	2,500
				(?)		Hazleton, Luzerne County	4,000
				Several lakes	Delaware River	Pike and Monroe Counties	5,000
				(?)		Somerset County	250
				Harvie's Lake		Luzerne County	5,000
				(?)		Wayne County	5,000
	Corry	Seth Weeks	10,000	Pond		Warren County	7,000
				Hatching ponds		Corry	3,000
Rhode Island	Ponagansett	J. H. Barden	9,500	Wallum Pond		Burrillville	5,000
				Maswansicut Pond		Scituate	2,000
				Steer's Pond		Scituate	500
				Warden's Pond		South Kingston	2,000
Vermont	Saint Johnsbury	Henry Fairbanks	24,000	Small ponds	Connecticut River	Saint Johnsbury	3,000
				Joe's Pond	do	Danville	6,000
				Style's Pond	do	Waterford	3,000
				Lake Willoughby	Lake Memphremagog	Westmore	3,500

				Bellwater Pond	do	Barton	3,500
				Greensborough Pond		Greensborough	2,500
				Harvey's Pond	Connecticut River	Barnet	2,500
Virginia	Blacksburg	M. G. Ellzey	10,000	Pond	New River	Wytheville, Wythe County	2,000
				Streams	do	Blacksburg, Montgomery County	8,000
West Virginia	Romney	Z. G. Graham	8,500	Fishing Creek		Wetzel County	5,000
				Bartlett's Pond		Near Parkersburg	100
				Dent's River		Marion County	200
				Meadow Run		do	200
				Branch of Buffalo Creek		do	100
				Prichard's Run		do	200
				Buffalo Creek		do	100
				Mill Creek		Hampshire County	500
				Dillon's Creek		do	800
				Trout Run			300
				Tributaries	Tygart's Valley River		1,000
Wisconsin	Geneva Lake	D. Sytle	5,000	Geneva Lake	Illinois River	Walworth County	5,000

TABLE V.—*Observations on temperature and weather at Grand Lake Stream, 1875–'78.*

Date.	Temperature. Air. 7 a. m.	Air. 1 p. m.	Water in midstream. 7 a. m.	Water in midstream. 1 p. m.	Water in enclosure. 7 a. m.	Water in enclosure. 1 p. m.	Wind and general remarks.
1875.							
Oct. 21	43	47	50	50½	......	......	N. W.; cloudy, except midday; rain shower a. m., and heavier in p. m. At 4 p. m. squall from N.
22	29	40	48	49	......	......	N. W., strong; clear weather.
23	34	36	48	48½	48	49	S. and S. E.; gentle, cloudy all day.
24	37	50	48	48½	48	49	Northerly; cloudy all day.
25	44	47	48	48½	48½	49	N.; medium, and threatening all day.
26	29	41	46	47	46	48	N., very strong; clear till mid-afternoon; froze mud hard last night.
27	41	47	47	47½	47	48	S. E.; strong in a. m.; N. W. in p. m.; calm in evening, cloudy, except occasionally toward night. Rain began about 3 a. m., rained hard till 10 a. m., occasionally through rest of day.
28	34	41	46½	47	46	47	N. W., very strong; clear; ground froze a little last night.
29	27	35	44	45	44	45	N. W., strong; clear.
30	30	41	43½	45	44	45½	Southerly, strong; clear.
31	40	45	44½	44½	45	45	S. E.; rain hard all day nearly.
Nov. 1	30	35	43½	44½	44	45	N., moderate; clear and then cloudy; snow begins very light at 10 p. m.
2	29	32	43	43	43	43	N. E., very heavy; snow and sleet all day.
3	31	36	42	43	42	43	N. W., heavy; cloudy; cleared at 12.15 p. m.; after cloudy.
4	30	33	41	41½	41½	42	Northerly; cloudy all day.
5	30	40	41	41½	41½	42	N. W.; clear.
6	25	35	40	41	40½	41	N. W., a. m. cloudy; p. m. clear; snow squall in a. m.
7	25	41	39½	40	40	40½	N. W., moderate; clear.
8	31	42	39	40	39	40	N. W., clear.
9	31	42	39	......	39	41	N. W., N. E. in evening. Partly cloudy, spitting rain and snow in evening.
10	33	43	41	41½	41	41½	S. and S. E., rain.
11	36	35	*	*	41	41	N. E. and N. W., rain, clear in evening; rained hard in morning; stopped in midday; cleared in evening.
12	30	42	......	......	39½	41	N. W., gentle; clear all day; evening calm and perfect.
13	33	47	......	......	40	41	Northerly, gentle; mostly clear in a. m.; some cloudy in p. m.; threatening to storm.
14	25	29	......	......	39	40	N. E., clear a. m., after cloudy; threatening to snow.
15	24½	31	......	......	38½	39	N. E., moderate; cloudy and threatening all day.
16	28	37	......	......	38¼	39	N. E. and S. E., clouds, rain and snow; snowed in early morning a little; rain followed by snow in evening.
17	27	28	......	......	37½	38	N. W., very heavy; snowed a. m.; clear evening; 3 or 4 inches of snow have fallen.
18	13	24	34½	......	33	35	N. W., very heavy; clear all day and evening.
19	22	32	......	......	34½	35	S. E., moderate; cloudy and threatening; spitting snow in evening.
20	27	32	......	......	35	35½	N. W., strong; clear; calm early this morning; calm, nearly, in evening.
21	10	36	......	......	34½	35	Southerly, moderate; cloudy and threatening. Grand Lake appears to be frozen over as far as Munson's Island. A little snow in evening.
22	10	16	......	......	32½	33	Northerly, night calm; wind changed in night and blew very hard; spring, 44°.
23	—3	20	......	......	33	33	S. W., gentle, cloudy; morning clear; snow at 3 p. m.; water in midstream at dam, 33°.
24	28	37	......	......	33	34	Varying N. W. to S. W.; clear mostly.
25	10	21	......	......	33¼	34	N. W., clear.
26	2	34	......	......	33½	34	S. W., cloudy and rain.
27	36	36	......	......	33½	34	N. W., increasing in force during day; in evening and night heavy; sky variable.
28	3	19	......	......	32	34	Northerly, change in midday to southerly; clear in early part, cloudy at night; spring at 10 a. m., 43°.
29	31	25	......	......	33	33	N. W., very strong; sky, variable; snow squalls in a. m. 4½ inches snow last night.
30	—16	—7	......	......	Frozen up.		N. W., strong; sky variable, mostly clear.

* The side channel that supplies the enclosures has been enlarged, and the temperature being now the same as in midstream, the observations in latter are now omitted.

TABLE V.—*Observations on temperature and weather at Grand Lake Stream, &c.*—Cont'd.

Date.	Temperature. Air. 7 a. m.	Water at the dam. 7 a. m.	Wind, and general remarks.
1876.			
Nov. 11	40	44	Rainy.
12	42	45	Rainy.
13	38	44	N. N. W., clearing; windy.
14	36	43	N. N. W., cloudy and wet; windy.
15	31	43	Northwesterly, partly cloudy.
16	25	41	Northerly, partly cloudy.
17	29	41	
18	28	41	
19	27	40½	Easterly, very light and southerly; partly cloudy; mostly pleasant.
20	29½	40	N. E., slight sprinkle of snow.
21	33	40	N. E., very strong; partly cloudy, partly pleasant.
22	33	40	N. E., partly pleasant.
23	38	40	N. E., cloudy; slight rain.
24	34	39½	N. E., slight rain and sleet.
25	28	38½	N. and N. W., cloudy; at hatching-house, 44½.
26	26	37½	Northerly, cloudy; sprinkle of snow.
27	27	37	Northwesterly, strong; cloudy; threatening.
28	23	36½	Northwesterly, strong; mostly clear.
29	22	35	Northwesterly; at hatching-house, 43.
30	12½	33	Westerly, pleasant.
Dec. 1	10	32½	N. E., cloudy and threatening.
2	21	32	N. E., cloudy; a little snow.
3	26	33	Northerly, light; cloudy.
4	28	33	Westerly, light; very pleasant.
5	19	33	Westerly, light; very pleasant.
6	11	33	Southwesterly.
7	21	33	S. to N. W., light; variable; cloudy and threatening midday; rest pleasant.
8	25	33	Westerly, light; mostly pleasant.
9	18	....	N. E., snow.
10	0	33	N. W., strong; snow 8 inches deep.
11	− 8	32½	Light, variable wind.
12	9	32½	N. E., snow heavy all day; about 1 foot snow.
13	9	32½	Variable, light; partly cloudy; at hatching-house, 42½.
14	22	....	Westerly; at hatching-house, 42–42½.
15	26	....	
16	13	....	At hatching-house, 42.
17	−20	32	N. W., pleasant.
18	−12	....	N. E., heavy snow.
19	0	....	N. W., cleared in night; snow 23 inches deep; last fall, 13 inches.
20	− 8	....	Westerly, medium; clear.
21	−14	....	Westerly, very light; clear a. m.; cloudy p. m.
22	6	....	Easterly, cloudy.
23	12	....	N. E., snow 3 or 4 inches.
24	5	....	Westerly, strong; pleasant.
25	2	....	Westerly, medium or stronger; clear, sunny, and pleasant.
26	− 9	....	Unsettled, light; cloudy.
27	15	....	Westerly, clear and cloudy.
28	3	....	Westerly, light; pleasant.
29	− 8	....	Easterly, light; mostly pleasant; cloudy p. m.; snow at night.
30	25	....	N. E., in p. m. westerly; began to snow at 9 p. m. yesterday; kept up, with a little hail, through the night; held up this a. m. (9), and had snowed 11 inches; about 1 inch after that during day.
31	9	....	N. W., strong.
1877.			
Jan. 1	3	....	N. W., pleasant.
2	8	....	N. E., strong; snow 6 inches.
3	0	....	N. W., clear.
4	− 6	....	N. W., clear.
5	− 2	....	N. W., clear.
6	−11	....	Variable; very light; clear and very pleasant; northern lights very bright.
7	23	....	S. E., snow 6 inches in a. m.; very light rain in p. m.
8	34	....	Southerly, thawing.
9	15	....	Westerly.
10	20	....	Westerly.
11	−11	....	E. and S. E., light; 2 inches snow last night; to-day pleasant.
12	− 8	....	N. W., strong; a little snow last night.
13	− 3	....	Easterly and westerly, light; 8 inches snow in a. m.; cleared at early p. m.
14	4	....	N. W., strong; clear.
15	−14	....	
16	....	....	
17	0	....	

TABLE V.—*Observations on temperature and weather at Grand Lake Stream, &c.*—Cont'd.

Date.	Temperature. Air. 7 a. m.	Temperature. Water at the dam. 7 a. m.	Wind, and general remarks.
1877.			
Jan. 18	−11	....	
19	....	....	
20	....	....	
21	....	....	
22	12	....	Variable; very light; cloudy.
23	− 7	....	N. W. and southerly, light; cloudy.
24	− 8	....	N. W., strong; clear.
25	−20	....	

Date.	Temperature. Air. 7 a. m.	Air. 1 p. m.	Air. 6 p. m.	Water at the dam. 7 a. m.	Water at the dam. 1 p. m.	Wind and weather.
1877.						
Oct. 4	54	58	60½	60	60	S. S. E., fresh; foggy.
5	53½	47	44½	60	59½	N. E., strong; rainy.
6	37½	53	44	55	56	N. W., fresh; clear.
7	37	50	39½	55	55½	Northerly, light; clear.
8	28	55	44	54	56	Southerly, gentle; clear.
9	39½	53½	49	54½	55	S. to S. E., light; cloudy.
10	48	56	51½	54	55	S. E., fresh; rainy.
11	49½	58	53	55	55½	S. E., light; rainy.
12	50½	55	49½	55½	56	S. E. to N. E., light; rainy; 1⅞ in. of rain.
13	43	48	44½	54	54½	N. E., strong; cloudy.
14	41	50	47	52	53½	N., fresh; cloudy.
15	40	54	50	53	54½	N. W., fresh; clear.
16	41	41	38	52½	52½	N. E. to N. W., light to fresh; rainy and cloudy; $\frac{1}{16}$ in. rain.
17	34½	45½	45	49	50	N. N. W., heavy; clear.
18	38	52	44	48	50	N. W., fresh; clear.
19	35	58½	47	49	50	S. W. to S. E. to N. E.; clear to cloudy to rain; $\frac{1}{16}$ in. rain.
20	34½	40½	33½	48	50½	N. W., light; clear.
21	24	42½	35	48	50	N. N. W., light; clear.
22	33	34½	35	48	47	N. E., fresh; snow, after melting, $\frac{3}{16}$ in. water.
23	31½	47½	43½	46	47	W., clear.
24	33	40	39½	47	48	Calm, cloudy; very light shower at noon.
25	31	33½	30	47	46½	S. E. to N. E.; snow.
26	24	35	32	44	45	N. to N. W., fresh; clear.
27	28	38	30	44	......	N. to N. W., fresh; clear.
28	29	43	35	44	45	N. W., fresh; clear.
29	30	46	50	44	44½	S. E., fresh; rain.
30	35½	50	41	44½	46	N. W., heavy; clear.
31	24½	45	41	44½	45	S. W. to S. E., light; clear to cloudy to rain; $\frac{5}{16}$ in. of rain.
Nov. 1	34½	44½	41	45	46	Variable, light; cloudy to clear.
2	31	39½	46	44	44½	S. E., fresh; cloudy to rain; $1\frac{7}{16}$ in. of rain.
3	41	50	40	45	45½	S. W. to N. W., partially cloudy; snow squall in p. m.
4	31	40	34	43	44	N. W., strong; clear.
5	28	42½	42	42½	42½	S. E., fresh; cloudy to rain; $1\frac{3}{16}$ in. rain.
6	39	34	29½	43	43½	N. W., very heavy; clear.
7	19½	40	34	40	42	S. W., light; clear.
8	23½	50	44	40½	42	S. W., light; clear to cloudy.
9	54½	60	57	44	45	S. to S. W., fresh; rainy; $1\frac{5}{16}$ in. rain.
10	28½	29	......	42	42	N. W., fresh; clear.
11	24	32	28	41½	41½	Northeasterly, light; partly cloudy.
12	25	34	32	41	42	N. W., fresh; clear.
13	29	34	28	39	39	N. W., fresh: clear.
14	20	44	40	38	40	S. W., fresh; clear.
15	30	49	46	40	41	S. W., gentle; clear.
16	46	54	53	41	42	S., light; rainy; ⅜ in. rain.
17	38½	46	36	41	41½	N. W., light; clear.
18	31	35½	36	40½	41	S. W., gentle; clear.
19	32	34	28	40	40	N. W., strong; clear to snowy.

TABLE V.—*Observations on temperature and weather at Grand Lake Stream, &c.*—Cont'd.

Date.	Temperature.					Wind and weather.
	Air.			Water at the dam.		
	7 a. m.	1 p. m.	6 p. m.	7 a. m.	1 p. m.	
1877.						
Nov. 20	26	28	27	37	38	N. W., strong; cloudy.
21	22	......	22½	36	......	S. E., gentle; clear.
22	18	31	23½	36½	38	N. W., gentle; clear.
23	27	42	33	37½	38½	N. W., gentle; clear.
24	31	43	......	38	39	Easterly, gentle; clear.
25	32½	36½	34	38	38	Easterly, gentle; cloudy.
26	37	42	42	38	38½	Easterly, fresh; rainy.
27	52	53	50	40	40½	Easterly, fresh; rainy.
28	44	......	43	40½	......	Easterly, light; rainy; $\frac{7}{8}$ in. of rain.
29	31½	36½	33	40	40	Easterly, gentle; cloudy to rain to snow.
30	31	34½	31	38½	39½	Easterly, gentle; cloudy.

Date.	Temperature.		Wind and weather.
	Air.	Water at dam.	
1877.	7 a. m.		
Dec. 1	24½	....	N., strong; clear.
2	8	....	Westerly, gentle; clear.
3	7	....	Calm to Southerly; clear to cloudy.
4	23	....	S. W., light; clear.
5	30	....	S. E., gentle; rainy.
6	42	....	Variable, gentle; rainy to clear; $\frac{15}{16}$ in. rain.
7	15	34	N. W., fresh; clear.
8	18	....	Southerly, gentle; snow to clear.
9	24	....	N. E., light; cloudy.
10	18	....	N. W. to S. E., light; clear to cloudy.
11	18	....	Easterly, light; snow.
	9 a. m.		
12	24	....	S. E. to N., cloudy day; clear evening.
	7 a. m.		
13	11	....	Southerly, light; cloudy to snow.
14	23	....	N. W., heavy; snow to clear.
15	8	32	Southerly, very gentle; cloudy.
	8 30 a. m.		
16	39	....	W. to N. W., gentle, to fresh clear, with squalls of snow.
	7 a. m.		
17	18	....	S. W. to N. W., gentle to strong; clear to cloudy, with squalls.
18	11	....	N. W., fresh to gentle; clear.
19	16	....	Southerly, light; cloudy.
20	33	....	N. E. to N., fresh; cloudy; clear evening.
21	12	....	Variable, very gentle; clear.
22	16	....	N. E., light; clear to cloudy.
	8 a. m.		
23	20	....	N. W., fresh; clear.
	8 a. m.		
24	23	....	N. W., fresh; clear.
	7 a. m.		
25	21	....	N. W., light; clear.
26	21	....	Variable, gentle; clear to cloudy
27	28	....	Westerly, gentle; clear.
	8 a. m.		
28	18	....	N. W., gentle; clear.
	7 a. m.		
29	16	....	Northerly, gentle; clear.
30	18	....	N. E., light; cloudy.
31	20	....	N., strong; cloudy.

TABLE V.—*Observations on temperature and weather at Grand Lake Stream, &c*—Continued.

Date.	Air.	Wind and weather.
1878.	7 a. m.	
Jan. 1	7	N. W., fresh a. m.; variable, light, p. m.; clear.
	7.45 a. m.	
2	18	N. E., gentle; cloudy to snow.
	7 a. m.	
3	3	Northerly, fresh; clear.
4	− 8	Easterly, light to strong; cloudy to snow.
5	28	Easterly to N. W., light; cloudy to clear
6	− 10	N. W., light; clear.
7	− 27	N. W., light; clear.
8	− 32	Westerly, light; clear.
9	1	S. E. to S. W., light; cloudy to clear.
10	− 3	S. E., light; cloudy to clear to cloudy.
11	37	S. E., fresh; rainy.
12	29	N. E. to N. W., cloudy to clear.
13	28	N. E., cloudy.
14	29	Easterly, rainy.
15	32	Variable, gentle; partly cloudy.
16	7	N. W., light; clear.
17	− 9	N. W. to S. W., light; clear.
18	− 8	Westerly and southerly, gentle; clear.
19	7	Westerly and southerly, gentle; clear.
20	30	Southerly, clear to cloudy.
21	33	Southerly and easterly, light; rainy.
22	33	Southerly and easterly, light; rainy.
23	33	S. W. to S. E. to N. E., light to a gale; snow.
24	− 10	N. W., fresh; clear.
25	15	S. W., gentle; partly cloudy.
26	19	Easterly, fresh; snow and rain.
27	22	Westerly, light; clear.
28	24	Calm, with snow; strong N. wind and cloudy at night.
29	− 2	N. W., fresh; clear.
30	− 8	Westerly, fresh; clear.
31	− 4	Variable, gentle; clear.
Feb. 1	10	N. E., fresh; cloudy.
2	2	N. W., fresh; clear.
	8 a. m.	
3	12	Northwesterly, light; clear.
	7 a. m.	
4	10	Northerly, gentle; cloudy.
5	18	Northerly and easterly, gentle; cloudy.
6	10	N. W., light; clear.
7	25	N. W., gentle; clear.
8	16	Southerly, gentle; cloudy.
9	32	Northerly, fresh; snow.
10	16	N. E., fresh; snow.
11	11	Northerly, light; partly cloudy.
12	− 8	Southerly, light; clear.
13	15	Variable, squalls of snow.
14	− 8	Northwesterly, light; clear.
15	− 9	N. W., light; clear.
16	− 8	N. W., light; clear.
17	− 2	Westerly, light; clear to cloudy.
18	10	N., strong; clear.
19	− 2	N. W., light; clear.
20	− 12	S. W., light; clear.
21	26	S. E., light; clear.
22	1	Easterly, fresh; cloudy.
23	30	Easterly, strong; snow and rain.
24	34	Westerly, gentle; cloudy.
25	− 28	N. W., light, clear.
26	− 26	N. E. to N. W., strong; cloudy to clear.
27	25	N. W., light; clear.
28	25	Variable, gentle; clear to cloudy, with N. E. snow squalls at night.
Mar. 1	6	N. W., strong to gentle; clear.
2	10	Southerly and easterly, gentle; mostly cloudy.
3	33	Southerly and easterly, gentle; rainy.
4	33	Northerly and easterly, fresh; cloudy, with squalls of snow and rain.
5	16	N. W., fresh; clear.
6	25	Southerly, light; clear to cloudy.
7	36	Southerly and easterly, light; cloudy.
8	33	N. W., fresh; clear.
9	31	N. W., light; clear.
10	33	N. W., fresh; clear.
11	20	N. W., strong; clear.

TABLE VI.—*General summary of observations on temperature at Grand Lake Stream from October, 1875, to March, 1878, inclusive.*

Date.	Air.					* Water in midstream.				Water in enclosure.			
	7 a. m.	1 p. m.	6 p. m.	Max.	Min.	7 a. m.	1 p. m.	Max.	Min.	7 a. m.	1 p. m.	Max.	Min.
1875.													
October	a35.27	a42.72	....	50	27	a46.68	a47.36	50½	43½	b46.27	b47.28	49	44
November	22.38	31.76	....	47	−16	c40.90	c41.47	44½	39	c37.46	38.19	45	32
1876.													
November	d30.10	....	....	42	12½	d39.97	....	45	33	....	....	....	....
December	8.26	....	....	28	−20	e32.84	....	33	32	....	....	....	....
1877.													
January	f0.86	....	....	34	−20	....	....	....	....	....	....	....	....
October	g36.71	g47.50	g42.73	60½	24	g50.34	g51.40	60	44	....	....	....	....
November	31.93	40.66	36.91	60	18	40.37	41.25	46	36	....	....	....	....
December	h19.21	....	....	42	7	....	....	....	....	....	....	....	....
1878.													
January	9.87	....	....	37	−32	....	....	....	....	....	....	....	....
February	7.88	....	....	32	−28	....	....	....	....	....	....	....	....
March	i25.09	....	....	36	6	....	....	....	....	....	....	....	....

* After November, 1875, temperature of water was taken at the dam.
a Average of observations from October 21 to 31, inclusive.
b Average of observations from October 23 to 31, inclusive.
c Average of observations from November 1 to 10, inclusive.
d Average of observations from November 11 to 30, inclusive.
e Average of observations made on 13 days between 1st and 17th.
f Average of observations made on 21 days between 1st and 25th.
g Average of observations from 4th to 31st, inclusive.
h Average of observations made on 26 days between 1st and 31st.
i Average of observations from 1st to 11th, inclusive.

TABLE VII.—*Measurement of Schoodic Salmon at Grand Lake Stream, Maine,* 1875.

Date.	Length of males.*					Length of females.*				
	Number measured.	Aggregate.	Average.	Longest.	Shortest.	Number measured.	Aggregate.	Average.	Longest.	Shortest.
1875.		*Inches.*	*Inches.*	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*	*Inches.*
Nov. 6	56	952	17	22	14.5	48	788	16.4	21	12.5
8	103	1,766	17.1	22	15	86	1,436	16.7	21	13
9	58	999	17.2	20.5	15.5	41	681	16.6	20	14.5
10	62	1,043	16.8	20.5	15	81	1,335	16.5	20	13
11	114	1,898	16.6	22	13.5	88	1,413	16.1	20	13.5
12	70	1,210	17.3	20½	14	105	1,743	16.6	20	14
13	36	597	16.6	20	14	75	1,239	16.5	20	14
15	41	678	16.5	20	14	94	1,536	16.3	20	13
24	111	1,848	16.6	20	14	257	4,187	16.2	21	13
26	74	1,222	16.5	20.5	13	120	1,898	15.8	20.5	13
Sums	725	12,213	16.8	22	13	995	16,256	16.3	21	12.5

* Length measured from tip of nose to extremity of the middle rays of the caudal fin.

TABLE VIII.—*Measurement of Schoodic Salmon at Grand Lake Stream, Maine, 1876.*

Date.	Males.*							Females, gravid, before spawning.†				Females spawned.†							
	Number weighed and measured.	Weight.			Length‡.			Number weighed.	Weight.			Number weighed.	Weight after spawning.			Number measured.	Length.‡		
		Average.	Heaviest.	Lightest.	Average.	Longest.	Shortest.		Average.	Heaviest.	Lightest.		Average.	Heaviest.	Lightest.		Average.	Longest.	Shortest.
1876.		*Lbs.*	*Lbs.*	*Lbs.*	*Inches.*	*Inches.*	*Inches.*		*Lbs.*	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*		*Inches.*	*Inches.*	*Inches.*
November 6	132	1.7	3.5	1	15.8	19	13	17	2	2.7	1.1	188	1.6	3.5	1	205	15.9	20	13
November 9	52	1.6	2.2	1	15.3	19	13	28	2.2	4.5	§0.7	187	1.6	3.5	0.7	209	16	20	12
November 11	31	1.5	2.2	1	15.7	18	13	24	1.8	3.8	1.1	120	1.5	2.7	0.9	141	16	20	12
November 14	23	1.6	3.1	1	15.7	21	13	8	1.7	2.2	1.2	92	1.4	2.7	0.7	100	15.9	20	13
November 18	19	1.5	2.5	1	15.3	19	13	2	2.5	3.7	1.2	62	1.5	3	0.7	63	15.8	21	13
November 21	17	1.6	2	1	16.2	19	13	......	......	......	......	19	1.4	2.2	0.7	19	15.5	19	14
November 22	5	1.5	1.7	1.2	16	17	15	......	......	......	......	12	1.4	2.1	0.9	12	15.5	19	14
Sums	279	1.6	3.5	1	15.7	21	13	79	1.9	4.5	0.7	680	1.6	3.5	0.7	749	15.9	21	12

* The same individual males were weighed and measured.

† The females measured for length included both the individuals weighed before and after spawning, except on 9th, 11th, and 18th, when several were weighed before spawning that were not measured at all.

‡ Length measured from the tip of the nose to the tip of the middle rays of the caudal fin.

§ This small fish was probably not yet adult, and may not have been female; barren or young fish of that size so much resemble females that they are not very readily distinguished.

TABLE IX.—*Measurement of Schoodic Salmon at Grand Lake Stream, Maine, 1877.*

Date.	Males.							Females, gravid, before spawning.							Females spawned.								
	Number weighed and measured.	Weight.			Length.*			Number weighed and measured.	Weight.			Length.*			Number weighed and measured.	Weight of eggs from same.	Weight after spawning.				Length.*		
		Average.	Heaviest.	Lightest.	Average.	Longest.	Shortest.		Average.	Heaviest.	Lightest.	Average.	Longest.	Shortest.			Aggregate.	Average.	Heaviest.	Lightest.	Average.	Longest.	Shortest.
1877.		*Lbs.*	*Lbs.*	*Lbs.*	*Ins.*	*Ins.*	*Ins.*		*Lbs.*	*Lbs.*	*Lbs.*	*Ins.*	*Ins.*	*Ins.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Ins.*	*Ins.*	*Ins.*
November 1	21	1.9	3.4	1.2	17.4	22	16	39	1.8	2.9	1.2	16.4	19	14.5	12	5.4	15.9	1.3	1.7	0.9	15.7	17	15
November 5	32	1.8	3.7	1.4	17	21	15	37	1.9	3	1.4	16.2	20	14	48	......	69.5	1.5	2	1.1	15.8	18	15
November 6	74	1.8	3.4	1.1	16.5	21	14	50	1.8	3.6	1.2	15.7	19	14	49	13.7	73.9	1.5	3	1.1	15.7	20	15
November 8	35	2	3.4	1.4	16.8	20	15	66	1.9	3.2	1.2	16	20	13	38	15	61	1.6	2.6	1.2	15.5	19.5	14
November 9	24	1.8	2.6	1.2	16.6	18	15	66	1.8	3	1.2	16.1	19.5	14	41	15.6	60	1.5	2.9	0.9	15.7	19	13.5
November 10	35	1.8	3.1	1.2	17	20	15	75	1.9	3.6	1.3	16.1	20	14	94	43.9	141.4	1.5	2.6	1	16	20	14
November 12	14	1.6	2.6	1.1	16.8	20	14.5	10	1.8	2.1	1.6	16.9	18.5	16	14	4.4	20.5	1.4	2.2	1.1	16.6	18.5	15
Sums	235	1.8	3.7	1.1	16.8	22	14	343	1.9	3.6	1.2	16.1	20	13	296	......	442.2	1.5	3	0.9	15.8	20	13.5

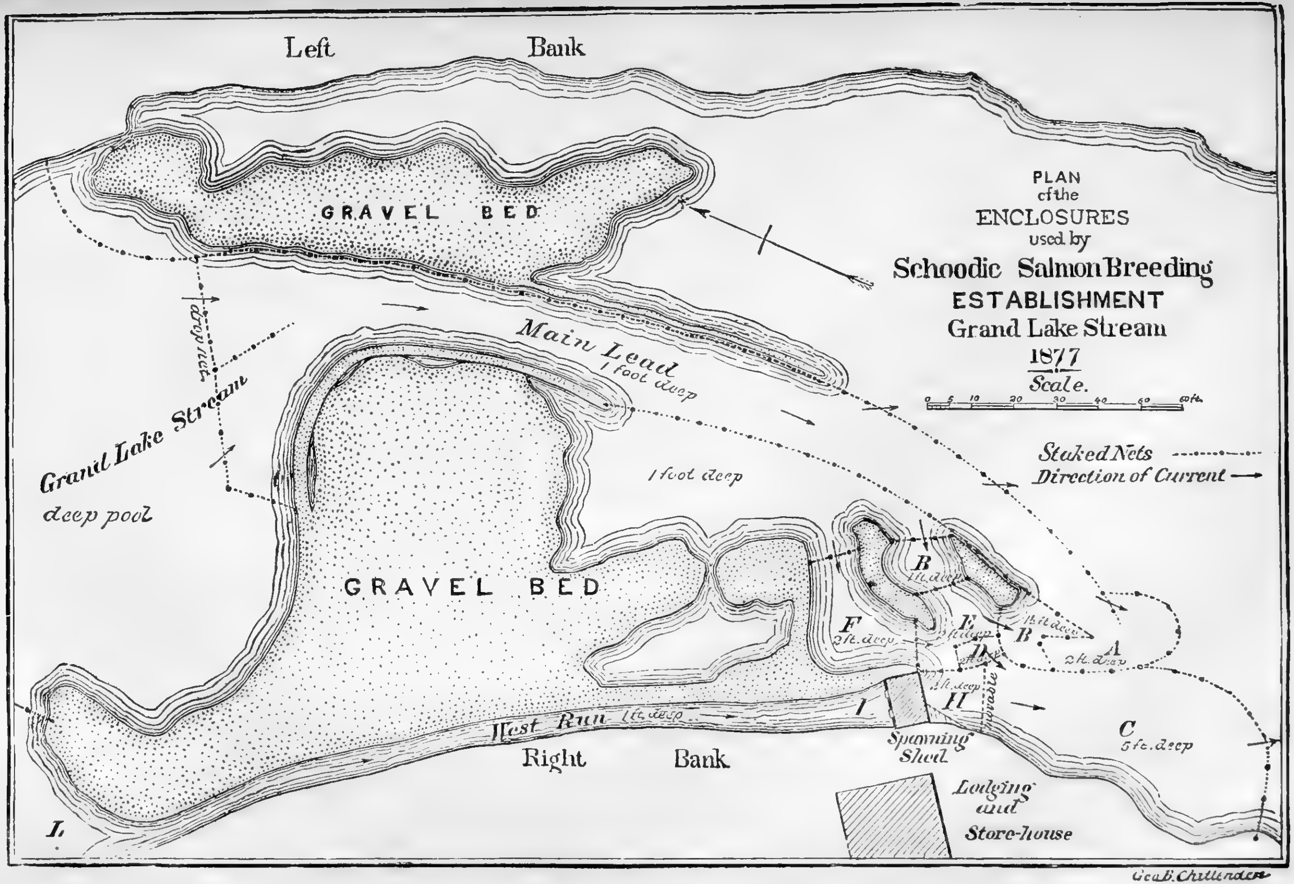
*Length measured from tip of nose to tip of middle rays of caudal fin.

TABLE X.—*Record of spawning operations, Grand Lake Stream, 1875.*

Date.	Fish at first handling.							Females spawned.		Females.		Number of eggs obtained.	Remarks.
	Total.	Males.	Females.				Barren.	First handling.	Afterward.	Total spawned.	Respawned.		
			Unripe.	Ripe.	Spent.	Total.							
1875.													
November 6	104	56	22	25	1	48	....	25	......	25	......	19,000	Caught 1 togue, 19 inches long.
November 8	192	106	43	42	1	86	....	42	......	42	23	35,200	Caught 2 brook-trout, 11 and 13 inches long, and 2 whitefish (*Coregonus*), each 13 inches long.
November 9	100	59	18	21	2	41	....	21	......	21	48	22,500	
November 10	142	62	28	52	0	80	....	52	......	52	......	44,500	
November 11	201	115	28	51	7	86	....	51	......	51	55	43,000	Caught 1 brook-trout 13 inches long.
November 12	178	72	32	72	1	105	1	72	62	134	......	95,800	
November 13	136	57	24	53	2	79	....	53	......	53	176	65,000	Sent 260,000 eggs to Dobsis stream; caught 1 togue, 20 inches long.
November 15	227	69	40	110	8	158	....	110	......	110	......	57,500	Sent 103,500 eggs to Dobsis stream.
November 16	67	26	10	28	3	41	....	28	7	35	110	39,000	Sent 19,000 eggs to Dobsis stream.
November 17	90	37	16	31	6	53	....	31	......	31	......	24,000	Took gravid female whitefish, 13 inches long, weighing 1 pound 4 ounces net; milted her eggs with salmon milt, but none developed.
November 18	60	24	6	25	5	36	....	25	80	105	......	73,000	Of 124 females handled second time, 44 are still unripe; took whitefish female, 13 inches long.
November 19	38	16	2	19	1	22	....	19	1	20	176	31,500	Took 2 whitefish, 1 ripe female, 1 barren; sent 136,000 eggs to Dobsis stream; Pocumpus Lake frozen over.
November 24	718	233	24	405	56	485	....	405	......	405	......	278,500	Began to overhaul the main pound in which fish have been collecting without our interference since October 25; took 1 togue, 2 whitefish, and 1 gravid female sea-salmon, 34⅝ inches long, weighing 10 pounds after spawning; she yielded 9,000 eggs, which were successfully milted with milt of Schoodic Salmon.
November 25	180	50	7	112	10	129	1	112	......	112	......	101,000	
November 26	193	73	5	86	29	120	....	86	77	163	......	129,500	Finished main pound, which was found to contain 978 Schoodic Salmon.
December 8	......	......	......	......	......	......	....	......	32	32	......	18,500	
	2,626	1,055	305	1,132	132	1,569	2	1,132	259	1,391	588	1,077,500	

TABLE XI.—*Record of spawning operations, Grand Lake Stream, 1876.*

Date.	Fish at first handling.						Females.		Number of eggs obtained.	Remarks.
	Total.	Males.	Females.				Total spawned.	Respawned.		
			Unripe.	Ripe.	Spent.	Total.				
1876.										
November 6	337	132	17	167	21	205	166		137, 500	Seined main pound and tried all fish on hand.
November 8							2	160	12, 000	
November 9	261	52	23	165	21	209	165		120, 000	Do.
November 10							2	163	15, 400	
November 11	172	31	21	107	13	141	107		80, 000	Do.
November 14	123	23	8	78	14	100	78		61, 400	Do.
November 16								170	30, 700	
November 16							98		35, 000	From fish found unripe on previous examinations.
November 17									12, 500	Eggs taken at Musquash Lake.
November 18								62	10, 000	
November 18	82	19	1	44	18	63	44		22, 300	Seined main pound.
November 20								71	3, 400	
November 21	34	15	0	8	11	19	8		2, 500	Do.
November 22	12	0	0	0	12	12			300	
	1, 021	272	70	569	110	749	670	626	543, 000	


PLAN
of the
ENCLOSURES
used by
Schoodic Salmon Breeding
ESTABLISHMENT
Grand Lake Stream
1877
Scale.
0 5 10 20 30 40 60 60 ft.
Staked Nets
Direction of Current
Left
Bank
GRAVEL BED
drop net
Main Lead
1 foot deep
1 foot deep
Grand Lake Stream
deep pool
GRAVEL BED
B
1 ft. deep
F
2 ft. deep
E
B
A
2 ft. deep
C
5 ft. deep
H
I
West Run 1 ft. deep
Spawning Shed
Right
Bank
Lodging and Store-house
L
Geo. B. Chittenden

EXPLANATION OF PLAN.

This plan represents the exact form and position of the fixtures employed in 1877, and they were substantially the same in 1876.

The left-hand edge of the drawing represents a line 50 or 60 feet below the dam which commands the flowage of Grand Lake. Immediately below the dam lies a broad, deep pool, part of which is shown on the plan. The dam itself is of the sort constructed by log-driving companies to store and control the water of lakes for the purpose of floating logs down the river, and is provided with deep sluice-gates, through which, when open, flows the water, which is never allowed to pour over the tops of the dams. In nearly all cases the gates are so low that fish can easily pass up or down, and this is especially the case with the dam in question. It is not looked upon as any hinderance to the descent or ascent of the salmon, except when the water is very low, as sometimes occurs in early autumn; but even then the situation is not such as to prevent the majority of them passing down into the stream. Great numbers of them collect in the deep pool just before the commencement of the spawning season, and there safely bide their time. From the pool the main current is through the artificial channel denominated the "Main Lead." Here the water is shoal and swift, and the bottom gravelly, and many fish are tempted to stop here and make their ridds. The majority, however, push on and are led by the nets into the inclosure A, from which they rarely find their way back into the main lead, but after a while are led into inclosure B. Here they are caught in dip-nets, counted and placed in C, which is deep and capacious enough for them to lie at ease; or, if the spawning time has actually arrived, they are placed for the night in E or D, and next morning examined and spawned so far as they are ready. The nets are all weighted by chains at the bottom, and by simply lifting them the fish can be driven underneath from one inclosure to another. When taking spawn the fish to be operated on are gathered without handling in front of the spawning-shed, at H. From the deep pound, C, they are drawn up by a seine or sweep-net. The fish from which eggs are taken are placed in F; those unripe in E or D, to be afterward driven into C. The males are divided and part of them placed with each party of females. After being pressed a second time, the fish are dropped out of apertures in the back of the spawning-shed into I, whence they run up to L, where is a deep pool for them to lie in until the spawning operations are at an end, when they are removed in cars to a safe distance in the lake.

XV.—THE PROPAGATION AND DISTRIBUTION OF SHAD IN 1877.

By James W. Milner.

A.—STATION ON THE SUSQUEHANNA RIVER NEAR HAVRE DE GRACE, MD.

Reference has been made in previous reports to the failure to procure a sufficient supply of shad in the southern waters of the United States to warrant the expense of establishing stations, the results having always proved greatly disproportionate to the outlay. In laying out the work for 1877, therefore, it was determined to concentrate effort upon the Susquehanna and Connecticut Rivers, with the object of obtaining a sufficient number of young fish from these two streams to meet the requirements in the way of stocking new waters. Another reason for concentration was the desire to test, during part of the season at least, the efficiency of a radical change planned and adopted by Mr. T. B. Ferguson, Maryland commissioner of fisheries, in the entire theory and practice of the hatching of shad, in dispensing entirely with the use of floating boxes of any kind whatever, such as had been hitherto considered absolutely necessary for successful work. These boxes, as the result of several years' experience, were found to answer an excellent purpose in comparatively narrow rivers, where there was a steady and continued current, but they were inadequate to the requirements in tidal waters.

As has been explained in previous reports, the floating boxes are connected in a gang by cords, the foremost one being held to its place by an anchor. During the strong tide-current there is sufficient movement of the eggs, but when the tide is slack they rest in masses upon the bottom of the boxes and in consequence suffer greatly, especially when the water is at a high temperature, unless shaken up by hand. In the event of a storm or freshet the boxes, except in the few sheltered places which are available in the region of the shad fisheries, are in great danger of being upset and the eggs and young fishes thrown out or carried away as has frequently occurred; and under the best of circumstances the exposure of the apparatus and the attendants to the elements, and the great number of boxes required to contain even a million of eggs at one time, are serious obstacles to their use when work is done on a large scale. In most tidal waters, and waters without current, as at the head of Albemarle Sound, these objections are fatal to success. It was therefore with much satisfaction that the experiments of Mr. T. B. Ferguson in the employment of an entirely

new process were observed, and a proposition to co-operate with the Maryland commission in carrying it out was most readily acceded to.

By the new method the work was to be done on floating barges or platforms, and the agitation, required for the eggs, imparted by the mechanical action of a steam-engine with its accessories. The work is prosecuted more or less under cover, and is capable of being conducted on a very large scale.

Early in the spring of 1877 Mr. Ferguson commenced his operations by borrowing from the authorities of the city of Baltimore four scows, formerly used in the transportation of stone for its piers and sea-walls. Each of these is about 60 feet in length and 20 in breadth, and one was properly fitted up with the necessary apparatus for the work, the propelling power being a steam-engine of 5-horse power, purchased by the United States Fish Commission and lent to Mr. Ferguson for the purpose. An arrangement was made with Mr. Ferguson for hatching such fish as might be needed by the United States Commission, their distribution to be under the direction of the latter. For the purpose of better accommodating the party under my direction while waiting for the production of the fish and their successive shipment to different points, one of these scows was fitted up by the United States Commission in a suitable manner, and placed in convenient relationship to a similarly arranged vessel of the Maryland Commission. The first locality visited for the shad work was situated in the Northeast River at the head of Chesapeake Bay; but for some reason this was found to be unsuitable, and the station was finally established in Spesutie Narrows between Spesutie Island and the Maryland shore, about six miles below the bridge at Havre de Grace. The actual work of shad-hatching commenced in the early part of May, and eggs were obtained at first principally from the ripe fish caught in the seines, but subsequently almost exclusively from the gill-nets. The season on the Susquehanna closed the 13th of June, up to which time there were distributed on the Atlantic side of the continent, in New England rivers, 1,477,000; in the Susquehanna River, 1,910,800; in the Southern Atlantic waters, 1,245,000; in the Mississippi and its tributaries, 1,158,000; and in the rivers of the Gulf of Mexico aside from the Mississippi, 110,000; in the Sacramento River of California 110,000 were placed, making the total number of shad distributed 6,010,800.

The accompanying tables exhibit the number of eggs taken, the number of fish hatched, and the distribution to different waters. The hatching apparatus (to be described hereafter) proved to be efficient and to possess all the superiority over the former method of the floating boxes that had been anticipated, especially in the success in hatching the eggs in waters where there was no current whatever. Another advantage not already referred to was the facility with which a cooler stratum of water could be reached when the surface was too hot for the proper development of the eggs, a condition always present when the

temperature rose above 80°. By covering the tops of the buckets by caps of wire gauze, they could be immersed to any required distance towards the bottom, where even the slight difference of heat might be enough to save the eggs. The apparatus, which was placed upon a large scow 59 feet long and 19 feet wide, consists of a shafting along the center of the scow upon which at intervals are placed irregularly formed cams which have a long and a short side. This is accomplished by making the outline of the cams two intersecting cycloid curves, which produces upon the lever following its circumference a quick fall and slow rise at the extreme end. A steam-engine is the motive power revolving the shafting and cams. To the ends of the levers are suspended cylinders of sheet-iron, from 1½ to 2 feet in diameter having a wire-cloth bottom, and within these cylinders the eggs are placed. The rise and fall in the water does not exceed 5 inches. A slow revolution of the shafting produces all the agitation in the water essential to the welfare of the eggs, a more rapid motion having a tendency to draw the eggs hard against the wire cloth. The slow rise and quick fall of the cylinders also prevents the eggs from this injury, as the effect is to throw the eggs high up as the bucket goes down, and as it comes slowly up they fall gently to the wire-cloth bottom.

B.—STATION ON THE CONNECTICUT RIVER AT SOUTH HADLEY FALLS, MASSACHUSETTS.

The work on the Susquehanna River closed on the 13th of June, and on the 26th of the month I commenced operations at South Hadley Falls, Massachusetts. We had shipped our stock of furniture in a freight car, and obtained a house in the vicinity of the fishery for the accommodation of the party; this proved to be very much more convenient in every way than a residence at the hotel over a mile from the fishery, as formerly. Seines and fishermen were at once engaged and began fishing, and the first eggs were taken on the night of the 26th. From that time until the fourth of August, eggs were taken every night, the entire number amounting to 3,161,000.

An immense raft of logs which was floated down the river over the spawning ground was a great detriment to our work, as, although the men in charge of the rafts were very obliging, in attempting to keep the logs as much as possible out of our way, still it proved to be a considerable interference with the fishing and the general success of our work.

Both at Havre de Grace and South Hadley Falls, Mr. H. J. Rice, of the Johns Hopkins University, of Baltimore, was with us, studying, by aid of the microscope, the embryological development of the shad. A portion of his conclusions having been published in the Maryland Report of Commissioner of Fisheries for the year 1877. Mr. Charles G. Atkins, of Bucksport, Me., also remained with us at South Hadley Falls during the season, making a large number of interesting and important experiments with reference to the impregnation of the eggs, and the care of the eggs and young fishes while in the hatching-boxes.

Mr. Frank N. Clark was sent on a reconnaissance to Windsor Locks, Conn., to determine the eligibility of that point as a hatching-station, but the season proved to be too far advanced for successful work. It is

It is asserted that the falls and dam constitute almost as complete an obstacle to the migration of the shad at this point as the dam at South Hadley Falls, although a law has been enacted by the State providing for a passage for the fish. A fishery has been established a few rods below which is carried on during the months of May and June. About the last week in June daily fishing is stopped, and the seine is hauled at intervals for the next two months and captures sturgeon, which are used almost entirely for local supply. During the last fortnight of regular fishing a sufficient capture of shad is made to warrant the success of a hatching-station nearly equal to that at South Hadley Falls, provided the fish are found to be ripe in this part of the river. The discovery that shad are in full spawning condition but a short distance above brackish waters in the Southern Atlantic rivers renders it probable that they are also so here. The testimony of the fishermen is to the effect that many ripe spawning fish are found in the season, and an adequate reward will probably follow the efforts of whoever attempts to propagate shad at this point.

The accompanying tables exhibit the extent of the work done here.

C.—TABLES OF SHAD PROPAGATION IN 1877.

Record of shad-hatching operations conducted at Havre de Grace, Md., on the Susquehanna River, from May 21, 1877,* *to June* 10, 1877.

Date.	Hour.	Temperature of—			Direction of wind.	Ripe fish.		Eggs obtained.
		Air.	Surface water.	Bottom.		Males.	Females.	
May 21	Noon	84	78	77	Change.	60	23	460,000
22	....do	83	78	73	N. W.	35	18	255,000
23	....do	70	75	64	N. W.†	20	10	145,000
24	....do	54	69	61	N. W.	4	5	100,000
25	....do	60	63	65	N. W.	6	8	140,000
26	....do	76	64	67	Change.	3	4	60,000
27	....do	70	65	66	S.‡	25	38	417,000
28	....do	69	67	66	S.	28	46	735,000
29	....do	73	71	66	S.	31	23	340,000
30	....do	78	73	71	S.	13	29	490,000
31	....do	74	71	71	S.	7	16	332,000
June 1	....do	78	74	71	S.	17	24	400,000
2	....do	85	75	74	S. W.	20	27	465,000
3	....do	83	77	77	S.	6	11	160,000
4	....do	80	76	78	S.	6	10	145,000
5	....do	76	76	77	S. W.	11	13	195,000
6	....do	73	75	76	Change.	4	6	95,000
7	....do	78	77	75	Change.	7	14	225,000
8	....do	84	79	79	Change.	6	8	125,000
9	....do	77	77	77	S.	2	4	55,000
10	....do	69	76	73	S. W.	1	3	45,000
								5,384,000

* For eggs obtained previous to this date see Report of Commissioners of Fisheries for Maryland.
† A heavy gale. ‡ Calm.

Record of distribution of young shad made from May 21, 1877, to August 8, 1877.

Date of transfer.		Obtained from—	Place whence taken.	Number of fish originally taken.	Introduction of fish.			Transfer in charge of—
					Place.	Stream.	Tributary of—	
May	21	Maryland Commission	Havre de Grace, Md	100,000	Saint Louis, Mo	Mississippi		L. Fairfax.
	22	do	do	100,000	Macon, Ga	Ocmulgee		H. E. Quinn.
	29	do	do	75,000	Montgomery, Ala			L. Kumlien.
	30	do	do	50,000	Sterling, Ky	Licking		F. A. Ingalls.
	30	do	do	46,000	Spesutie Narrows	Susquehanna		United States Fish Commission.
	31	do	do	100,000	do	do		Do.
	31	do	do	100,000	Milledgeville, Ga	Oconee		C. D. Griswold.
	31	do	do	150,000	——, Md	Elk		United States Fish Commission.
June	1	do	do	100,000	Topeka, Kans			H. E. Quinn.
	1	do	do	56,000	Spesutie Narrows	Susquehanna		United States Fish Commission.
	2	do	do	100,000		Potomac		L. Fairfax.
	2	do	do	126,000		Bohemia		United States Fish Commission.
	2	do	do	285,000		Sassafras		Do.
	2	do	do	150,000	Cumberland, Md	Potomac		L. Fairfax.
	2	do	do	127,000	Spesutie Narrows	Susquehanna		United States Fish Commission.
	3	do	do	12,800	do	do		Do.
	4	do	do	100,000	Saint Joseph, Mo	Missouri		L. Fairfax.
	4	do	do	100,000	Canton, Miss	Big Black		F. A. Ingalls.
	5	do	do	100,000	Spesutie Narrows	Susquehanna		United States Fish Commission.
	5	do	do	510,000	Denton, Md	Choptank		Do.
	6	do	do	110,000	Tehama, Cal	Sacramento		F. N. Clark.
	6	do	do	72,000	Spesutie Narrows	Susquehanna		United States Fish Commission.
	7	do	do	30,000	do	do		Do.
	7	do	do	160,000	Laurel, Md	Patuxent		C. D. Griswold.
	8	do	do	50,000	Spesutie Narrows	Susquehanna		United States Fish Commission.
	9	do	do	100,000	Covington, Ga	Ocmulgee		C. D. Griswold.
	9	do	do	20,000	Spesutie Narrows	Susquehanna	Chesapeake Bay	United States Fish Commission.
	10	do	do	60,000	do	do	do	Do.
	11	do	do	20,000	do	do	do	Do.
	11	do	do	100,000	Seaford, Md	Nanticoke		Do.
	11	do	do	100,000	Salisbury, Md	Wicomico		Do.
	11	do	do	100,000	Railroad Crossing	Pocomoke		Do.
	12	do	do	100,000	Appleton, Wis	Fox		James W. Milner.
	12	do	do	10,000	Spesutie Narrows	Susquehanna	Chesapeake Bay	United States Fish Commission.
	13	do	do	36,000	do	do	do	Do.
	13	do	do	50,000	Cockeysville, Md	Gun Powder		L. Fairfax.
July	4	United States Fish Commission	South Hadley Falls, Mass	12,000	Smith's Ferry	Connecticut		C. G. Atkins.
	4	do	do	90,000	Springfield, Mo	James	White	F. A. Ingalls.
	5	do	do	110,000	Mexico, Mo	Salt Creek	Mississippi	C. D. Griswold.
	9	do	do	90,000	Waterbury, Vt	Winooski	Lake Champlain	R. E. Earll.

Record of distribution of young shad made from May 21, 1877, to August 8, 1877—Continued.

Date of transfer.	Obtained from—	Place whence taken.	Number of fish originally taken.	Introduction of fish.			Transfer in charge of—
				Place.	Stream.	Tributary of—	
July 12	United States Fish Commission.	South Hadley Falls, Mass.	118,000	Tennessee	Forked Deer	Mississippi	F. A. Ingalls.
13	do	do	110, 0 0	Columbus and West Point, Ga.	Chattahoochie		C. D. Griswold.
14	do	do	50,000	Rhode Island	Blackstone		Rounds.
14	do	do	80,000	Fulton, Ark	Red		R. E. Earll.
16	do	do	110,000	Mumfordsville, Ky	Green		F. N. Clark.
16	do	do	145,000	Smith's Ferry	Connecticut		C. G. Atkins.
16	do	do	110,000	Harts' Store, Va	Dan		H. E. Quinn.
17	do	do	207,000	Smith's Ferry	Connecticut		C. G. Atkins.
18	do	do	50,000	Rhode Island	Blackstone		Rounds.
18	do	do	100,000	North Carolina			J. F. Ellis.
19	do	do	100,000	do			F. A. Ingalls.
20	do	do	60,000	South Hadley Falls			
20	do	do	100,000	Saint Paul, Minn	Mississippi		H. E. Quinn.
23	do	do	165,000	Smith's Ferry	Connecticut		Clark & Atkins.
23	do	do	50,000	do	do		C. G. Atkins.
24	do	do	75,000	New Hampshire	Merrimac		Weber & Powers.
25	do	do	100,000	North Carolina			C. D. Griswold.
28	do	do	50,000	New Hampshire	Merrimac		Weber & Powers.
28	do	do	50,000	Middleboro', Mass	Taunton		R. R. Holmes.
30	do	do	100,000	Smith's Ferry	Connecticut		William Smith.
31	do	do	80,000	do	do		C. G. Atkins.
31	do	do	50,000	Bridgewater, Mass	Taunton		R. R. Holmes.
Aug. 1	do	do	33,000	Smith's Ferry	Connecticut		C. G. Atkins.
3	do	do	27,000	do	do		Do.
4	do	do	14,000	do	do		William Smith.
7	do	do	85,000	Maine	Penobscot		H. J. Rice.
7	do	do	22,000	Smith's Ferry	Connecticut		William Smith.
8	do	do	62,000	do	do		Do.
			6,210,800				

XVI.—THE EXPERIMENTS IN PROPAGATING MAIFISCHE (ALOSA VULGARIS), IN 1876 AND 1877.

By R. Eckardt.*

On the 26th of May, 1876, I received by Privy-Counselor Fastenau the honorable commission from Chamberlain von Behr-Schmoldow, president of the German Fishery-Association, to undertake a journey to the Rhine, in order to effect if possible in this year the increase and spread of the "maifische"† by artificial raising.

I must here mention that Mr. Christian Schieber, of Hameln, superintendent of fisheries, had made very thorough investigations of this whole matter in Wesel, from May 7 to June 9, 1875, and in Neuwied, Coblentz, Neuendorf, and Berncastel, on the Moselle, from the 13th to the 28th of May, 1876, and had ascertained that spawning "maifische" are but rarely caught in those localities. The fishermen say that the "maifische" in that neighborhood do not spawn till June, and sometimes not till July, but that this did not occur every year.

On the 8th of June I was able, after having arranged some private matters connected with my farm, to set out for Hameln, via Berlin, in order to obtain from Mr. Schieber an oral account of his observations. He very readily communicated to me all he knew, and showed me his very favorably located and practically arranged salmon-breeding establishment, as well as his interesting contrivances for catching salmon and eels, which were in full operation during the time of my visit.

The breeding establishment is fed by very pure spring-water, of 7.5 + Réaumur ($48\frac{3}{4}$° F.), which comes from the ground in the immediate neighborhood, is caught in two covered wells only 10–15 meters distant, and is led through underground pipes. The water does not leave any oxides

* Report of Mr. R. Eckardt-Lübbinchen, landed proprietor, on the experiments in propagating the "maifische" (*Alosa vulgaris*), made in 1876, at the request of the German Fishery-Association, and on the continuation and successful termination of these experiments in 1877, by artificially breeding and raising these fish, transporting them, and by stocking the rivers Elbe and Neisse with them. "Bericht des Rittergutsbesitzers R. Eckardt-Lübbinchen über die im Auftrage des Deutschen Fischerei-Vereins im Jahre 1876 angestellten Versuche zur Vermehrung der Maifische, sowie über die Fortsetzung und glückliche Ausführung dieser Versuche im Jahre 1877 durch Künstliche Befruchtung, Erbrütung und Transport wie Aussetzung in Elbe und Neisse." From Circular No. 5 of the German Fishery-Association. Berlin, July 17, 1877. Translated by H. Jacobson.

† It has been deemed expedient to retain throughout this article the German name of the *Alosa vulgaris*, viz, the "maifische."

either in the wells or in the hatching-channels or in the round clay breeding-vessels, and is consequently free from mineral, chiefly metallic, substances which are easily oxidized, and although it does not come in contact with the air until it reaches the hatching-channels, it is nevertheless well suited for hatching salmon-eggs, as more than a million have been hatched in it. I cannot but mention in this connection the fact, long since proved satisfactorily to my mind, that all spring-water, and other water, too, contains a quantity of air sufficient for maintaining organic beings, but that spring-water is but rarely free from mineral, particularly easily oxidized metallic, substances and gases, and that consequently organic beings cannot live in it without sustaining some injury. If such mineral water is led into an open ditch or into a small pond, large enough, however, to bring the water which flows in for twenty-four hours in contact with the air, the mineral substances are oxidized to such a degree that, unless there is any putrefying organic matter in the pond, it will become capable of sustaining animal life, and be well suited for a hatching-pond.

Salmon-fishing was still going on in Hameln; on the 9th of June, from 6 to 8 a. m., eight had been caught, and from 8 to 10 a. m. ten, with an average weight of 11 to 15 pounds apiece, and the salmon were still ascending the river. To me the leaping of the salmon endeavoring to get over the large weir, three meters in height, which spans the Weser, was a most interesting sight. Toward noon, when the sun is very bright, some salmon succeed in getting across, but by far the larger number are caught in the nets.

The salmon-fisheries, which formerly were rented out by the city of Hameln for $214 annually, rent now for $3,770, a very palpable proof of the success of artificial hatching. The city pays Mr. Schieber, for his trouble in hatching one million salmon for the Weser, about $100.

I left Hameln at 1 p. m. on June the 9th, and reached Coblentz late in the evening.

On the 10th June, early in the morning, I visited Mr. Joseph Glöckner, in Neuendorf, in whose possession were most of the hatching-boxes which had been prepared for hatching "maifische."

Mr. Glöckner had ceased to catch "maifische" for this season, because there was no sale for them, and because they had been caught in such large numbers that people had gotten somewhat tired of them; the lease of his fishing district was, moreover, soon coming to an end, and he did not wish by catching very large quantities to raise the rent any higher. As I learned afterward, he was not successful, for his rent has been raised from about $21.42 to upward of $238.

Next year he was going to produce "maifische" capable of spawning; this year it was too late to do this, and if it did not get warmer they would not spawn, any way. In consequence of many violent thunder-storms the temperature had fallen to 59° F., and it was raining incessantly.

He was of opinion that in spite of all prohibitory regulations a great

deal of damage was inflicted on the Rhine and Moselle fisheries by renting out the fisheries to capitalists who understood nothing about fishing. He likewise informed me that people were allowed to use nets with narrow meshes for catching *Cyprinus alburnus*, from the scales of which artificial pearls are manufactured in Paris, and that this was a great trade in Cologne. But with the small *Cyprinus* many young salmon, "maifische," pike, perch, lampreys, barbel, pollard, mackerel, &c., &c., are caught, which being of no use to these fishermen, are destroyed. By catching so many *Cyprinus* the quantity of food for the finer class of fishes is diminished, and catching and destroying so many young salmon of course does incalculable harm to the salmon-raising. Mr. Glöckner thought that until these abuses were stopped the Rhine fisheries would not amount to anything.

The same opinion was expressed to me by the following superintendents of fisheries: Georg Weber in Irlicht, Christian Wattler in Cologne, Hackenbroik and Schlömer in Dale near Deutz, all of whom urged me to do all I could for having these abuses stopped.

As no spawning "maifische" could be obtained from any of these gentlemen, I came to the conclusion that the "maifische" must spawn farther up the Rhine or its tributaries, and I therefore went to St. Goar, where there are large salmon fisheries belonging to the town, and was told by Mr. Robert Herpell, inspector, and Mr. Klein, superintendent of fisheries from St. Görshausen, that near St. Goar and as far up the Rhine as Bingerbrück the current was too strong for catching "maifische." I was likewise informed by these gentlemen that many "maifische" were caught in the Neckar above Mannheim. I therefore traveled direct to Ludwigshafen and remained there over night with the intention of making further inquiries at Heidelberg the next day.

At 8 a. m. on the 13th of June I arrived in Heidelberg in a pouring rain. I immediately went to see some of the prominent fishermen, and from them got all the information I desired; but could unfortunately not put it to any use, as the Neckar had risen $1\frac{1}{3}$ meter during the night, and its water was very muddy. The "maifische" do not like such water, and let themselves be driven down the stream by it, so that within a quarter of an hour about 30 "maifische" were handed to me from a stationary fishing-apparatus which had been placed out in the stream, among these 3 entirely firm "spawners," which, however, were not yet ready to spawn. From the 23d to the 29th of May the weather had been remarkably fine, and the "maifische" had spawned in the Neckar in such enormous quantities as never before, and the spawning season for the stragglers extends till near the end of June. Spawning might consequently still be observed if only the water would get clear and the weather be favorable; but from all signs the rainy season had not yet come to an end. As I had no time to wait any longer, I went home and sent Mr. Wilke, the superintendent of my fisheries, to Heidelberg to make further investigations. The weather did unfortunately not get any better; thun-

derstorms accompanied by hail and rain made the Neckar a roaring torrent, and enormous quantities of "maifische" went down the stream, so that no spawner was caught. Mr. Wilke therefore returned on the 24th of June without having attained the object of his journey.

As the result of my observations for this year may form some sort of guide for next year, I will mention the following:

1. From the beginning of May the Neckar fisheries, from Mannheim to Heilbronn, should be carefully watched with a view of catching spawning "maifische."

2. Suitable hatching-places should be prepared and every arrangement made for quickly transporting fish by railroad.

3. The superintendent accompanying the fish should receive a permit from the managers of the different railroads to stay with the fish in the baggage-car all the time, and he should also have the privilege to use fast or express trains.

4. The manager of this whole enterprise should be allowed to exercise his own discretion in making the necessary investigations, in engaging assistants, and in making all the required arrangements.

5. The most suitable stations for placing young "maifische" would be Fulda on the Weser, Dresden on the Elbe, and Guben on the Oder.

6. The fishing association of Seckenheim, Ilvesheim, and Fendenheim would be the best for trying the experiment of raising "maifische" in an artificial manner.

On the 8th of May, 1877, I was again commissioned by Chamberlain von Behr-Schmoldow to make experiments on the Rhine and Neckar to obtain if possible artificially-hatched spawn of "maifische," and transplant the young fish into the Elbe, Oder, or Neisse. At 5 a. m. on the 14th of May I left my home in company with Mr. Müller-Tchischdorf, superintendent of fisheries, and reached Heidelberg at 10 a. m. on the 15th.

As my investigations of the previous year had taught me that the best way to reach my object would be to place myself in direct communication with the fishing association of Seckenheim, consisting of sixteen members, who have the privilege of fishing in the Neckar with a large net from Mannheim upward as far as the mill at Bergheim, we immediately went to see these persons, traveling via Mannheim by railroad, hack, and on foot.

We found these fishermen enjoying a rest in a frame hut, where they kept their provisions and implements. We immediately informed them of the object of our visit, and placed ourselves on a friendly footing with them. I handed them my card, from which they could see that I had also something to do with fishing, and promised to pay them $3.50 for the first female "maifische" suitable for artificial hatching.

The fishermen seemed favorably inclined toward our enterprise, but were doubtful of its ultimate success. They promised, however, to do all in their power to further it, and thus we left them in order to get our hatching-boxes, vessels for transporting fish, &c., which had been left

behind at Heidelberg. It was a very comforting assurance which the fishermen made to me, that so far they had not caught any "maifische" that were ready to spawn, all the more so as I had been somewhat frightened by the assertion which Director Haackat-Hüningen had made on the 1st of May at the piscicultural congress, that this year the "maifische" would already spawn in the Rhine, which assertion has fortunately not proved true.

On the 16th of May Mr. Müller went down the Neckar in a boat, with seven hatching-boxes and two vessels for transporting fish, and took his station at Feudenheim, where he arranged everything for his experiments. Various articles, such as a file, pincers, wire, tin, a thermometer, a microscope, &c., were procured at Heidelberg and taken along by him. I went to Heilbronn, in order to gather further information regarding the ascent of the "maifische" in the Neckar, and visited Mr. Friedrich Drantz, who owns the Neckar fisheries a few miles below, and has rented them out to three fishermen, whom he has given certain regulations for protecting the fish. This gentleman informed me that in his fisheries "maifische" were only caught in very exceptional cases; that they scarcely ever go up as far as Heilbronn, where there is a stone weir, and were not found beyond that place.

On the 17th of May I again went to Seckenheim via Mannheim, gave orders to have the covers of the hatching-boxes arranged in a simpler and more practical manner, and had ten new boxes made, as dissecting a female "maifische" had convinced me that three to four boxes might be required for all these eggs, and we might consequently be short of boxes. The weather was cool all the time, and on the Neckar never higher than 13°–14° R. (61°–64° F.), and the air was raw, which makes the fish disinclined for spawning. If the weather got warmer, the fishermen told us, spawning fish might be caught next week.

On the 18th of May I went to Coblentz and Neuendorf, via Mayence, to visit Mr. Joseph Glöckner. He was just engaged in catching "maifische," but none of the females which he had caught were ready to spawn. I paid him the money which he had laid out for sending hatching-boxes to Basle, Hüningen, and Heidelberg, and asked him to go on with the hatching process as soon as he caught any spawning "maifische." He took a deep interest in this matter, and told me that last year he had got artificially impregnated spawn of the perch and had hatched it in the boxes, and that on the 26th of June he had caught a very fine specimen of a female "maifische" ready for spawning, that he had immediately impregnated the spawn artificially, and had placed it in the hatching-boxes. This spawn had remained in good condition for some days, but one morning he found that it was all white and dead. I told him that this was caused by the fine mud contained in the Rhine water, which stuck to the lower part of the sieve and finally covered the eggs entirely; in future he should twice a day take off this mud with a brush from the outside of the box, for thus a new current was

created and the eggs were saved, as the little mud which remained would be rubbed off by their rolling against each other in the box. I also asked him to send word to me at Heidelberg as soon as any "maifische" spawn had been hatched.

On the 19th of May I returned to Seckenheim and found some boxes which Mr. Müller had placed in the Neckar, and in them some "maifische" eggs which had been impregnated before maturity, and with which Mr. Müller was making further experiments, with a view of eliminating bad eggs and of learning the general way of treating the eggs. After many experiments it became quite clear to us how the "maifische" eggs should be treated. We got another strong brush, and Mr. Müller made a spoon of wire-gauze, with a wooden handle, with which the eggs could easily be taken up; the bad ones could then be picked out with a pair of pincers and the good ones put in a special box by themselves, so they could not suffer from being mixed together. Thus all our arrangements had been perfected, and nothing was wanting but the fish.

On the 20th of May, Whitsunday, I went to Freiburg to see the mayor of that city, Mr. Schuster; from there I went to Basle on the following day to see Mr. F. Glaser; from there to Hüningen, returning to Heidelberg late at night. Mr. Schuster met me at the depot and showed me his excellent fish-hatching establishment, and we agreed as to the manner of artificially hatching "maifische" eggs, which I said I would supply to him, as I felt certain that the eggs packed according to my own fashion would arrive in good condition.

Early on the 21st of May I went to Basle, in order to have an interview with Mr. Glaser, to whom a hatching-box had been sent. I found him at one of his seven salmon-fisheries, about one-half (German) mile farther up the river. The hatching-box had already arrived, and we quickly nailed it together and placed it in a suitable location in a gentle current. Mr. Glaser told me that the "maifische" were so far entirely unfit for spawning, and had, in fact, only come in his neighborhood a few days ago, so that but few had been caught. He had placed two in a basin in his garden, but one, the male, had died, and the female was living peacefully together with carp, gold-fish, &c., but seemed to be very restless. Mr. Glaser intended to put another couple of "maifische" in another basin, to put a male fish to the deserted female in the first basin, take out the other fish, and let the spawning process go on undisturbedly. He said that he moreover intended to get artificially impregnated eggs in his salmon-fisheries and hatch them, letting me know the result. Unfortunately I have so far not heard from him, although I have written to him several times.

From Basle I went to Hüningen to see Director Haack and his extensive hatching establishment, which has been greatly improved by him. The most interesting part to me were the very ingenious arrangements for raising the finer kind of food-fish, all the specimens showing an excellent condition and healthy growth. Here one can see what may be done

in this respect even under the most unfavorable local circumstances, and what a great and promising future there is in store for pisciculture in this special branch, if once it has been rightly understood and the proper interest taken in it. It is an unfortunate circumstance that we neither possess the means to make researches in this field more general, and to make full use of the knowledge gained thereby, nor that we can offer to those men who under the greatest difficulties and at their own expense make these researches and gain this knowledge any public position which would be remunerative, but that we must invariably refer them to their private enterprise; and therefore we always meet them as fishermen, who must make their living by the fisheries but who have very little time left for any questions of general interest. They consequently remain stationary on that slightly varying step of knowledge where accident has placed them. In my opinion there is no field of human knowledge for which the state should provide educational institutions as much as that of pisciculture. I shall have occasion to refer to this question again, and I hope sincerely that my remarks may contribute their share in spreading more knowledge as to the ways of increasing articles of human food, so that nature's vast treasures are not, as has been unfortunately the case, wasted from sheer lack of knowledge how to use them.

After having been hospitably entertained by Mr. Haack and his estimable lady, I returned to Basle, accompanied to that city by Mr. Haack, where I took leave of him, my heart full of bright hopes regarding pisciculture and its future. Arriving in Heidelberg at 5 a. m. on the 22d of May, I took a short rest, and, as Mr. Müller had sent me word that there were as yet no spawning "maifische" to be seen, I went to Würzburg, in order to gain further information from Mr. Seifried, one of our oldest pisciculturists, who had formerly lived in Mayence, and who was well acquainted with the river Main and its fisheries. Mr. Seifried showed me his trout-raising establishment in Zell, and told me that occasionally a few "maifische" had been caught in the Main in former times, but that for many years none had been seen there. He thought this was caused by the great quantity of refuse from various factories which get into the Main, but in my opinion other causes have brought about this change.

I here learned to know a fish-dealer and trout-raiser, Mr. Carl Helmstädter, who had worked for six years in American piscicultural establishments, among the rest in the one owned by Mr. Seth Green, and who gave me a great deal of interesting information. Wherever I went I gathered information corroborative of my supposition that the Neckar from Mannheim till below Heilbronn would be the only location where sooner or later we would reach our object. Very well satisfied with my excursion, I returned to Heidelberg, and on Wednesday the 23d of May I again went to Seckenheim to see Mr. Müller, and found some well impregnated eggs taken that morning. Mr. Müller had the process performed by a fisherman, and had afterward himself squeezed $\frac{2}{3}$ of the

eggs out of the fish and impregnated them at a temperature of the air of 9° R. (52°. 25 F.), the water temperature being 11° R. (56°. 75 F.) The eggs were nearly all in excellent condition; about fifty or sixty thousand were put in the box, and the few bad ones were picked out by means of Müller's gauze spoon, and everything passed off successfully. Through our little microscope we could distinctly watch the process of impregnation.

On Thursday, the 24th of May, I was again in Seckenheim, and convinced myself of the healthy further development of the eggs. I now resolved to make experiments in transporting the impregnated eggs, and believing that the third day after impregnation would be the most suitable time for this, I made all the necessary arrangements and wrote to Mr. Von Behr in Schmoldow, to Mayor Schuster in Freiburg, and to the superintendent of my own establishment at Lübbinchen. My letters contained the following: "On Saturday, the 26th of May, I shall send to your address by mail a small number of impregnated 'maifische' eggs, and would ask you to let me know the number of good and bad eggs and of young fish." In Schmoldow the majority of the eggs arrived on the third day in good condition; of 894 eggs sent to Lübbinchen, 694 were in good condition and 200 were spoiled; in Freiburg, where the eggs arrived the next day, only 50 eggs proved good after they had been placed in a box. Mr. Müller took further care of the eggs, and was all the time on the lookout for more spawners, while I, on the 26th of May, once more went to Neuendorf to see Mr. Joseph Glöckner and ascertain whether there were any "maifische" in the Rhine. The "maifische" had unfortunately gone, and none were caught. Returning to Mr. Müller, on the 27th of May, I found about 150,000 eggs all in excellent condition, which had been impregnated the day before my arrival. There were among this number scarcely any unripe, spoiled, or unimpregnated eggs. The first eggs of the 23d of May had already far advanced in their embryonic development, so that the shape of the fish could be distinguished.

On the 28th of May, another batch of 100,000 eggs were artificially impregnated, but among these a number of white, *i. e.*, spoiled eggs showed immediately; these were picked out on the following day, and the development went on in its normal course. On the 29th of May the fishermen caught only 26 "maifische," and on the 30th only 11, so that the association dissolved.

As I had learned that the Heidelberg fishermen, forming an association of 12 members, Mr. Peter Rohrmann being president, had, on the 28th of May, caught upward of 400 "maifische" at the fish-weir near Neckarhausen, and they were going to fish again on the 31st of May, I made arrangements with Mr. Rohrmann, at Heidelberg, to leave at 5 a. m. on the 31st for Neckargemünd, to go from there to Neckarsteinach, and witness the fishing from one of the fishing-boats. I committed the care of the eggs to Mr. Rautelder, a gentleman eminently fitted for this duty, and left Heidelberg, accompanied by Mr. Müller, in a pouring rain.

Upward of 300 "maifische" were caught during our presence, but unfortunately there was among them not a single one ready to spawn, but many with spoiled eggs; so, in spite of all our efforts, we could not obtain any suitable eggs.

On the 1st of June, at Seckenheim, I saw the first young "maifische" which had slipped out of the eggs. I took 2 fish and 3 eggs in a glass vessel to Heidelberg, where I placed them in a larger vessel, and observed, to my greatest delight, that the fish came out of the eggs in an entirely healthy condition; the same was the case with 3 eggs of a pollard, which had also been artificially impregnated. I was now in a position to make a direct experiment as to how these young fish would stand the journey. I was delighted to notice that I could warm them in the sun to a temperature of 17° R. (70°. 25 F.), that they did not need any fresh Neckar water till after two days, that in three days they had absorbed the umbilical bag, and that they developed in a remarkable manner if Neckar water was given to them twice a day. I thus felt confident that they would stand the journey.

On the 2d of June I telegraphed to Chamberlain von Behr that the young fish had left the eggs. I likewise telegraphed to his excellency Minister von Nostitz, in Dresden, that 100,000 young "maifische" would arrive in that city at 8.24 a. m. on the 8th of June, and to Mayor Kämpffe, at Guben, that the same number would arrive there at 1.40 p. m. of the same day. I asked that two fishermen might be at the Dresden depot to receive the fish, as I had only one hour's time; at Guben I asked for a formal reception at the depot.

On Sunday, the 3d of June, Peter Rohrmann was going to make another haul near Neckerhausen; but this intention was frustrated by the very sudden rising of the Neckar, which made its water quite muddy; but, as this only lasted a short time, our young fish did not suffer at all from it.

On the 4th of June I made another excursion to Neckarhausen, got a few more "maifische," but none of them contained any good spawn. I then had a few more caught, and placed them in a basin in the botanical garden in Heidelberg, to see whether they would keep healthy, and perhaps spawn there; two were dead the next morning and one the following evening. The basin was intended for aquatic plants, and was arranged in four separate divisions, producing many sharp corners, against which the "maifische" had rubbed and thus hurt themselves. I spoke with Mr. Pfitzer, professor of botany at the University at Heidelberg, about making an artificial hatching-place for "maifische," which could be fed with Neckar water, but owing to their peculiar circumstances he could give me no encouragement.

On Tuesday, the 5th of June, I visited Mr. Müller, in Seckenheim, to see in what condition the young "maifische" might be. The water was still quite thick, but the fish were in a healthy condition. They could only be seen when taken from the water with a small dipper. All the necessary

arrangements for the journey were perfected. On Thursday, the 7th of June, at 4.40 p. m., we were to leave Mannheim by the through-train, and I was to come to Seckenheim at about 11 a. m. with a carriage, place the fish in my two vessels, and fill a third one with ice.

On Wednesday, the 6th of June, I paid a visit to Mr. A. Pagenstecher, professor of zoology at the University of Heidelberg, to ask him to examine some "maifische" eggs which I considered unripe or spoiled. He very cheerfully promised his co-operation, and said that if he could pursue his observations for several years, he felt convinced he would find the causes of this and explain it scientifically; he was, moreover, inclined to favor the establishment of artificial hatching-places, and showed me a large salt-water aquarium, which, however, contained no animals. He has, unfortunately, no Neckar water for the "maifische," and this is absolutely required; for in the hard well or brook water, with a low temperature, they cannot be hatched.

On Thursday, the 7th of June, I started on my journey, going first to Seckenheim in a hack; here Mr. Müller placed the young "maifische" in two vessels, and filled a third one with ice. The road from the river to the Mannheim turnpike was a little rough, but we got over it safely and soon reached Mannheim. Here we unfortunately made a mistake and got in the train which only goes as far as Frankfort-on-the-Main; in this city we had therefore to transfer our fish to another depot, and then traveled uninterruptedly to Corbetha; here we had to change cars again, as the train on which we had come went through to Halle and Berlin, while we wanted to go to Dresden.

In Dresden we were met at the depot by Privy Counselor Koch, by Mr. Friedrich, and Mr. Klemm, superintendents of fisheries, who received the fish. Mr. Müller had time to place them in the river, while I was kept busy transferring the other vessel to the Guben depot, which took about half an hour. The remaining half hour I spent with the above-mentioned gentlemen in the depot restaurant, where I showed them some young "maifische," which I carried with me in a bottle; these fish, however, are so transparent and small, that they can only be seen after the eye has become a little practiced. Through Mr. Koch I also sent a live specimen to his excellency the minister. At 9.30 a. m. we left Dresden, the thermometer being 25° R. (88°. 25 F.) in the shade, and arrived in Guben at 1.40 p. m., where we were met at the depot by Mayor Kämpffe, several members of the city council, Count Reventlow, governor of the district, and many landed proprietors, all desirous of being sponsors on the occasion of these young German natives of the Rhine and Neckar being baptized with Neisse water.

The few young "maifische" which I had with me in a glass were still in good condition, although the temperature of the water was 23° R. (83°. 75 F.) but they died before we reached Lübbinchen during the long journey in the hot sun performed in an open carriage.

I have still to make the following general remarks: On the 23d of

April of this year the fishermen of Seckenheim have commenced to fish for "maifische." The first were caught on the 28th of April, and the largest number on the 10th, 11th, and 12th of May, none of them, however, ready for spawning. About as many fish were caught as in 1875, but only one-third as many as in 1876, in which year the "maifische" in this district were ready for spawning between the 23d and 29th of May, and have spawned very freely in the Neckar.

From the mass of information gained this year the following points may deserve special consideration for the future:

Along the Neckar there are three fishing districts which are suitable for obtaining artificially impregnated eggs of "maifische:"

1. The district of Seckenheim where the first and the largest quantity of eggs may be obtained during spring if the temperature is not too cold. The sixteen members of the fishing association presided over by Mr. Johann Raufelder have all the necessary apparatus, and take a deep interest in the matter. In this district, therefore, the first spawning "maifische" are found, because it is tolerably warm and possesses great advantages for fishing with a seine.

2. The district of the Bergheim Mill, extending past Heidelberg as far as Ziegelhausen. Here fishing is carried on by the various fishermen living along the river; in favorable years many spawning "maifische" are caught near the Bergheim Mill and near Ziegelhausen.

3. The district of Neckarsteinach and Neckarhausen, extending up the river as far as Hirschhorn. This district is colder and has much rocky bottom, and the fish consequently spawn somewhat later in the season. There is here a fishing association of twelve members, presided over by Mr. Peter Rohrmann in Heidelberg. This year the largest number of "maifische" were caught in this district, but their eggs were not at all developed and many were spoiled.

During a favorable year artificially impregnated eggs may, therefore, be obtained in Seckenheim early in the season, a little later in Heidelberg, and still later in Neckarhausen.

As soon as the Rhine rises to its high-water mark in spring, many "maifische" come into the Neckar, because they cannot be caught in the Rhine; the same is the case in the Neckar in the three above-mentioned districts which lie one above the other.

For hatching the "maifische" eggs in the Neckar the American floating hatching-boxes are well suited; but as the current cannot well be regulated, a simple wooden screw is fastened in the front part of the floating frame, by means of which the box may be placed higher or lower according to the different currents.

As soon as the eggs have been hatched, *i. e.*, after five days, they must be placed in well-protected boxes covered with the finest kind of gauze, or better still with a firm glass bottom and gauze-covered openings on both sides which permit the water to flow through.

Such an apparatus may be furnished by having three small boats con-

nected in front and behind by strong ropes, and perhaps surrounded by a light frame-work of floating timber; between every two boats there is a frame holding two rows of the boxes mentioned above, placed at such a distance that they can easily be reached from the boats.

The large outer frame-work must in front and behind be protected by boards connected at an angle, so that the boxes are safe from strong currents and waves, wind-storms, and floating objects, such as scum, dirt, wood, grass, &c. On the outside the floating apparatus for hatching may still be fastened for four or five days.

Boats for this purpose may be rented in Mannheim for 23 cents a day; the floating timber and all the necessary wood-work can be furnished by a carpenter in Seckenheim, and nothing would remain to be done but to prepare the stationary hatching-boxes, in which the young "maifische" immediately after having left the eggs, and in fact the eggs themselves before they are hatched, are perfectly safe. This apparatus, which is absolutely necessary, which facilitates the whole process very much, and which is a strong protection for the eggs and young fish, may, after the "maifische" season has come to an end, also be used for hatching other Neckar-fish, as the perch, the pollard and others, which are hatched in 3 to 4 days, lose their umbilical bag in 4 more days, and may then be placed in any river. Such an apparatus, or several of them, which can easily be taken to pieces and stored away, should be found in every fishing district; this would be the best way of increasing the number of river fish, and the result would be seen in two or three years. The leading principle for the healthy development and increase of the river fish must, however, invariably be found in the catching of the fish during the spawning season, and in the artificial impregnation of all the eggs that can be obtained; in this way the eggs are saved from the numerous fish of prey which devour them and inflict incalculable damage to the fishing interests during the spawning season.

The young fish can easily be transported in any tin cans. We had to change cars quite a number of times during our journey, and the fish stood these changes very well, so that about 70,000 young "maifische" could be placed in the Elbe and as many in the Neisse. The best temperature for transporting "maifische" is 12°–15° + Réaumur, which can easily be furnished by placing ice in the neck of the tin can; air is not required during so short a journey.

In future it will be best to place the "maifische" destined for the Elbe in the Saale near Halle, where the through train from the south arrives at 4.28 a. m. The fish destined for the Neisse would leave Halle for Guben at 8.5 a. m. by express train. If, therefore, the fish leave Mannheim at 4.40 p. m. they need not change cars till they reach Halle, so that the whole journey may be accomplished without any difficulty.

If the number of fish sent should amount to several million, a special baggage-car might be engaged at Mannheim.

I clip from my diary the following table of temperatures:

May 15.	Water, 14° R.	63.50° F.;	air, 15° R.	65.75° F.	
16.	14	63.50	16	68.00	
17.	13	61.25	14	63.50	
18.	12	59.00	13	61.25	
19.	11	56.75	12	59.00	
20.	11	56.75	12	59.00	
21.	11	56.75	12	59.00	
22.	10	54.50	11	56.75	
23.	9	52.25	10	54.50	1 fish; 500,000 eggs.
24.	9	52.25	10	54.50	
25.	10	54.50	9	52.25	
26.	10	54.50	11	56.75	1 fish; 150,000 eggs.
27.	12	59.00	14	63.50	
28.	13	61.25	16	68.50	1 fish; 100,000 eggs.
29.	13	61.25	16	68.50	
30.	13	61.25	13	61.25	
31.	12	59.00	14	63.50	The fishermen ceased to fish.
June 1.	13	61.25	16	68.00	
2.	14	63.50	14	63.50	
3.	16	68.00	23	83.75	
4.	16	68.00	25	88.25	
5.	17	70.25	28	90.50	
6.	17	70.25	28	90.50	
7.	16	68.00	22	81.50	
8.	16	68.00	25	88.25	

During the best time 100 to 200 fish have been caught in Seckenheim every day, and in Neckarhausen 430 and 350 at a single haul. These fish find their market in Frankfort-on-the-Main, Mannheim, Strasburg, and other cities along the Rhine. Their sale, however, comes to an end with the 31st of May, for although even in June some very fine "maifische" are caught, there is a prejudice against eating them during that month.

The fishermen, unfortunately, do not take the proper care of the fish which they catch; after every haul they are piled in an open boat, covered with a little grass, so as to protect them against the rays of the sun and the air, and are then brought to market the next day. The price is not very high; early in the season 23 to 39 cents are paid for a "maifische" weighing $3\frac{3}{4}$–5 pounds, and soon it gets down to 20 cents and even less.

No one ever thinks of smoking these fish, because the fishing season is of such short duration, and the results vary so much in the different years, that it would scarcely pay for any one to come from a distance and erect the necessary buildings.

I was told that a Frenchman had in former times smoked the "maifische" in Heidelberg, had only paid $1\frac{1}{2}$ cents apiece to the fishermen, and had nevertheless become bankrupt. As long as the "maifische" are only increased in the natural way the object of fishing for them will only be to sell fresh fish; but if they are increased artificially, and conse-

quently in much larger numbers, it will almost become necessary to smoke them in order to avoid a waste. All the smoking establishments, however, should be under strict government supervision, so that no fish are smoked which have spawned and are in a poor sickly condition, and might produce epidemics if extensively used as an article of food. Such fish and all the other refuse might be mixed with alkaloids and make a very excellent fish guano. In the above I have only briefly indicated the great importance of raising "maifische," and I only hope that we may soon succeed in raising millions of these useful fish.

XVII.—THE EXPERIMENT OF TRANSPORTING TURBOT AND SOLES FROM ENGLAND TO AMERICA.

By Fred Mather.

When I left New York, October 13, 1877, for Germany, with salmon-eggs, an account of which has been rendered, I also carried orders to return by way of England and make the experiment of transporting Turbot and Soles for stocking the waters of Massachusetts Bay. I was provided with a letter to Mr. Thomas J. Moore, curator of the Museum at Liverpool, who had kindly offered to assist in the enterprise, and furnish such facilities for keeping the fish until ready as the capacity of the salt-water aquaria of the Museum would permit. I had also a letter from Mr. J. G. Kidder, of Boston, to Messrs. W. Cunard & Co., London, reminding them of their generous offer made two years previously to Messrs. Baring Bros., of free transportation to an agent of the United States Fishery Commission, together with the tanks of fish. I had, through the liberality of Oelrichs & Co., New York, the same privilege, should I wish to return via Southampton and New York, but as the fish were destined for the vicinity of Boston, it was deemed advisable to return by the Cunard Line from Liverpool.

Arriving at Southampton on the evening of November 12, I spent four days attending to some personal matters, and started for Liverpool on the morning of the 17th, where I arrived at 2 p. m., and reported to Mr. Moore, who, having considered his own tanks inadequate both in size and circulation to support so many animals in addition to the regular occupants, had arranged with the Great Aquarium at Southport for the storing of the fish, and decided on this point as possibly the easiest to collect from at this season. The next day being Sunday, we postponed our trip to Southport, a fashionable watering-place, twenty miles north, until Monday.

November 19.—I went to the office of D. & C. McIver, agents, Cunard Line, Liverpool, and presented the letter from Mr. Kidder, and was referred to Mr. Cunard, London, who replied that he would be pleased to hear when the fish were ready. Mr. Moore and self left at noon for Southport, met Mr. John Long, curator of the aquarium, and saw the fine store-tanks in the "naturalists' room"; they are of slate, 8 by 12 feet, and 3 feet deep, with a plentiful flow of water and a subdued light; here new specimens are acclimated before placing in the show-tanks. Mr. Long thinks that we may get what we wish, and sent for a fisherman, Thomas Ball, to meet me in the morning.

November 20.—I met Ball. He catches shrimps for feeding the aquarium fish and for market; gets small soles in quantity from 3 to 4 inches long; seldom gets large, marketable fish, except in summer; he agrees to catch me 100 small soles for 30 shillings. Too stormy to fish to-day, so I try and get some information about these fish, of whose habits I know nothing.

I am told that it is of no use to try for large soles with the men who fish for market, as at this time of year they go far out and stay from three days to a week, using heavy trawls that require an hour or more to raise; hence they leave them down for nearly a whole tide, and when raised the fish are mostly dead. In the summer soles are found near the shore and in the mouths of rivers, but at the approach of cold weather, or during storms, they seek deeper waters. Fishermen say that the shifting sand near shore in stormy weather gets in their gills, which they do not like, although they often bury the greater part of their bodies in sand or shingle in quiet water. Ball fishes with what is called a "shank" net, something like a beam-trawl, but smaller, and dragged somewhat faster over the sand and weeds for shrimp. Still blowing too hard to fish. Heard of a "Lemon Sole" in market; went to see it, and found that it was not Günther's fish of that name, *Solea aurantiaca*, but a species of Flounder, *Pleuronectes microcephalus*, also called "Lemon dab" and "Smooth dab"; it is sold much cheaper than the sole, and in great quantity. Stormy weather continued with more or less violence until November 29.

November 29.—Ball fished; got eleven small soles, which he says are not the true variety, but a kind that grows no larger. Mr. Long disputes this, and I incline to accept his opinion, as based upon a scientific acquaintance with British fishes. To make sure, however, and provide against all chances of error, I procured Couch's illustrated work on "British fishes," and Gunther's "Catalogue of fishes of the British Museum," and found by presence of pectoral fin on lower or white side, and other characters, that Mr. Long was correct, and that the specimens were neither the "Little Sole" or "Solonette," *Solea minuta*, Gthr., which is common in Cornwall and the west coast of England, and has its eyes near each other and jaws nearly equal with a projection of the lower instead of the upper jaw, as in *S. vulgaris*, and the nostrils very close in front of the right eye; nor the one known by the names of "Variegated Sole," "Thick back," "Bastard Sole," and "Red-backed Sole," *S. variegata*, Gthr., which seldom grows over 8 or 9 inches in length, and is not esteemed for the table; this species is characterized by having its lower eye smaller and in advance of the other. These and *S. aurantiaca*, referred to above, which has no pectoral fin on the blind side, being all that I had to beware of, made it certain that I would not mistake an allied form for the right one *S. vulgaris;* and although I proved the fisherman's notion false, it had the good effect of putting me on guard in collecting fish with which I was unfamiliar, and thus teaching me that there was danger

of getting a wrong and insignificant fish in waters where, finding but one species in market, I was previously unaware of their existence.

November 30.—Eleven of the soles procured yesterday were dead this morning; many of them show red blotches on the white side as if blood was congested there from injuries; put them in spirit for the Smithsonian Institution. High wind and rain; no fishing.

December 1.—At suggestion of Mr. C. L. Jackson, consulting naturalist of the aquarium, I hired a boat and two men, and we went out to fish one tide with a beam-trawl. Result: five small soles and a great quantity of flounders from 1 to 3 inches long. The fishermen now say it is too late in the season for soles, and regret that I did not arrive a fortnight earlier. This is the usual consolation for collectors everywhere.

December 3.—Fleetwood, still farther up the coast, is a famous place for soles. Went there; same story—"too late." Dropped a line to a fisherman at Bangor, Wales, to know if any were to be had below Liverpool.

December 6. Weather has been good and the men have fished, but caught no soles. A letter from Bangor gives no hope. The five caught on the 1st, and the two on hand, are dead, and it looks like a hopeless task to get enough for a trial; for if they will not live a week in the aquarium they certainly will not on the ship, and I had reluctantly made up my mind to return without them, when Mr. Long offered me his nearly full grown ones from the show-tanks where he had fed them to their present size from yearlings of 3 inches, and of which he had between twenty and thirty specimens.

December 7.—Wrote Mr. Cunard that the fish would be ready to go at his earliest convenience. The men caught twenty small soles to-day, but all died before getting them ashore; they say that soles will die in a can if there is a frost, no matter what the temperature of the water inside may be. This is surely untrue; possibly they may not stand a certain degree, but the men evidently do not know the dying point. Mr. Long states the extremes of temperature at Southport pier as 45° and 68°. Thought it well to know how they would stand water without circulation, and so I put a sole 6 inches long in a gallon of water at noon, and looked at it every half hour; at 9 p. m. it seemed as fresh as ever, and I thought if it would live nine hours in a gallon, it might live twelve as well, and changed the water, measuring it with a half-pint glass; woke up in the night and suddenly remembered that I had only put in twelve half-pints instead of sixteen; fish alive at 9 a. m., apparently ignorant of my blunder, and lived until 9 p. m., twenty-four hours, when I considered that it had undergone trial enough, and replaced it in the tank alive and well. In this experiment it is fair to state that, being placed in the bottom of an oval can 2 feet by 1 wide, with one end slightly raised, there was a comparatively great amount of surface exposed, and the oxygenation consequently better than is usual in a transportation can. There is a Cunard

ship advertised to leave for Boston every Thursday; am in hopes to go on the next one, which leaves on the 13th.

December 8.—Mr. Long has offered to lend me two heavy galvanized iron cans, each 4 feet 3 inches long by 2 feet 6 inches wide and 2 feet high; these are elliptical in shape, with a top piece 6 inches wide riveted on all around, with a flange an inch wide dropping from it, into which the cover fits. These cans may be returned by next steamer; or, if there is a prospect of returning for more fish in the spring or early summer, they may be stored until then.

December 10.—Men at 9 p. m. reported thirty-five small soles in the boat, but could not be reached until daylight; gave a man a shilling to bring them early in the morning.

December 11.—The fish reported yesterday were all dead this morning; it has been cold, but no frost; begin to think that these small soles do not stand the rough handling or bruising of the trawl; this is partly confirmed by Mr. Long, who says that half or more of those caught in summer die.

December 13.—Day for ship to sail, but no letter from Mr. Cunard.

December 15.—Wrote again, asking if it would be possible to leave in the next ship, leaving on the 20th.

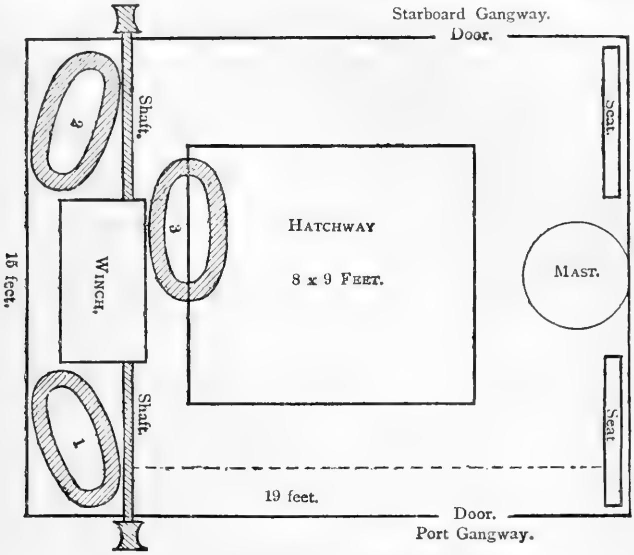
December 18.—Letters from Mr. Cunard and Messrs. McIver, both saying that there will be no ship of their line leaving for Boston before January 3.

Mr. Jackson suggested also taking a few turbot for trial, to learn how they would bear transportation, and thought that the sand which I had been advised to put in the cans might in a heavy sea have its lighter particles in such constant motion as to interfere with their gills, and that it would be better to substitute shingle. Mr. Long also approved of this, and it looked quite reasonable to me then, and so that was decided upon.

January 2, 1878.—Went to Liverpool and procured my ticket, and called on Mr. Moore. It was decided to get on board at the dock, which the ship left at 9 a. m., the passengers leaving the landing by a tender at 10. To do this the fish must leave Southport at 7, and stop at Bankhall, a suburb of Liverpool, Mr. Moore very kindly promising to have a conveyance and two men in readiness at the station, where there was a flight of thirty-six steps to carry the cans up and required six men, but which saved about three miles cartage. Telegraphed Mr. Long that the fish should be caught to-night. On arrival at the aquarium, found the fish had been taken from the show-tanks and placed in the store-tanks.

January 3.—The fish were put up and the programme fully carried out. In one tank were six turbot, each 11 inches long by 8 broad, and three soles; the other contained twenty-three soles, the smallest 9 inches in length, and the largest 12½ by 6 broad, each can having a quantity of gravel in the bottom. In carrying up the steps the gravel all got in one end, and I feared for the fish. The ship was the Siberia, Captain McKay,

of the Parthia, temporarily in command, and we hauled into the river, took on passengers, and sailed at 11 a. m. The cans were in a place called by the sailors the "fiddler," nearly amidships on the main deck. The upper deck does not cover the whole width of the vessel at this point, hence doors open from the "fiddler" on an uncovered gangway, from which plenty of fresh air can be had. A hatchway occupied the middle of this room, and a steam-winch for hoisting freight, one end; the floor was covered with a wooden grating, so that any quantity of water could be spilled and run down and out of the scuppers. It was used by cabin passengers as a smoking-room. The accompanying diagram will show the arrangement and assist my explanations.



1. Can with 6 turbot and 3 soles.
2. Can with 23 soles.
3. Second position of No. 1.
Dotted line, hidden steam-pipe.

The cans were securely fixed back of the winch-shaft in the places marked 1 and 2, No. 1 containing the turbot, two of which were dead at midnight.

January 4.—Two more turbot and one sole dead this morning. Water in No. 1 has got hot; on examination I find the steam-pipe that heats the cabins runs under the grating in the course marked by the dotted line, and of which I was not aware; the water being 72°, or 22° higher than at 8 a. m. Had it removed on the hatch and lashed to the winch in place marked 3. My arrangement was that I attended to them and aërated the water every three hours from 8 a. m. until midnight; the sailors washed decks at 4 a. m.; then the boatswain put the hose in the cans for a few minutes, and I was up between 7 and 8 again, so that they were never more than four hours without attention. There were now four of the six turbot dead, and one on its back; cooled the water gradually and changed it; turbot turned right side up.

January 5.—Turbot that was weak is dead.

January 6.—Found a sole out of the can on the grating—sailors let the water on too strong; the fish being alive was put back. Sailors promise more care; spoke to them about temperature, cautioning not to use hose if the water was cold, no danger, however, until near the banks of Newfoundland.

January 7.—All looking nicely; men washed another fish out at 6 p. m.; find it is another set of men in kindness giving the fish an extra change.

January 11.—This morning found the last turbot and fifteen soles dead; the water at midnight was 42°; this morning at 7.30 it is 46°. The men say that they were all right at 4 when they changed the water; it has been very cold during the night; perhaps the fish were killed by a sudden change of warm water at about 58°, but which had cooled down before my arising. Emptied one tank, put it over the steam-pipe, threw out the gravel which had bruised some of the fish, and put the remaining six soles into it.

January 12.—On the banks; very cold; three of the soles dead and one missing; the two remaining ones were brought through alive without change of water from this until the 16th.

January 16.—Cape Cod light visible; took the two soles out in a bucket to get the temperature down from 58° at 6 a. m.; at 7 they are at 44°. On consultation with the captain as to the best place for deposit, there not being enough to warrant employing a boat to go out from Boston, he recommended "Stelwagen bank," some two or three miles off Nahant, a sandy bank separated from a rocky shore by blue mud. At 8.30 we reached this place, and I lowered the bucket near the surface and emptied it by a cord attached to the bottom. This was in 18 fathoms of water, the surface temperature of which was 31°, while that in the bucket was 36°; had no means of getting the bottom temperature.

The temperatures during the trip were as follows, that of the air being *in* the room and bore very little relation to that outside:

Date.	Air in room.				Water in cans.				Remarks.
	6 a. m.	M.	6 p. m.	12 p. m.	6 a. m.	M.	6 p. m.	12 p. m.	
	°	°	°	°	°	°	°	°	
Jan. 3	49	54	52	50	50	50	50	52	
4	52	58	59	58	51	54	56	55	Water in No. 1 at 11 a. m., 72°, from steam pipe; four turbot dead.
5	62	62	59	60	56	55	56	55	One turbot dead; weather beautiful.
6	62	59	60	60	55	53	54	54	But little motion to ship.
7	63	64	63	65	56	56	57	57	
8	58	57	50	53	58	58	55	56	
9	47	47	46	46	54	51	50	52	Rolling heavily; can hear the gravel in cans.
10	51	48	44	46	55	50	46	45	Cold; snow; quieter,
11	40	43	44	43	46	48	53	55	Last turbot and fifteen soles dead.
12	41	45	50	46	60	62	62	62	Only two soles left; ship rolling.
13	55	60	60	59	62	62	60	61	No water added from yesterday during remainder of trip.
14	58	54	54	55	62	60	61	62	Calm and warm.
15	50	51	51	50	62	62	61	60	Colder and rough.
16	40	......	......	......	58	......	......	......	Planted two soles at 8.30 a. m.

I have not the least doubt, from the appearance of the fish, but what all the deaths that occurred before the 15th were from bruises occasioned by the shingle, as, besides the congested appearance mentioned, one of the turbot had the lower opercle torn and the gill injured. I would not use any substance for them to bed in, notwithstanding they love to bury themselves. I think that there is little danger of a sole being injured by friction on the bottom, for they can stick fast there or on the sides at pleasure. I have even seen them in the aquarium holding to the glass. Do not remember seeing turbot do this, but think that possibly they can hold to the bottom as other flat fish do. I noticed that neither of these fish have ribs protecting the abdominal cavity, which is particularly exposed to injury. The majority of them dying on the morning of the 11th, between the change of water at 4, and my arrival at 8, at once shows something wrong in the water. The two soles that were in the can with the turbot were well on the fatal morning, and might not have had a change; the men were contradictory on this point; were put with the others that survived, making six, all of which died except two, but their identity was lost, and I cannot say if they were the survivors.

However, the fact of getting two across safely proves that soles, and perhaps turbot, can be brought over under more favorable circumstances, though I cannot conceive of a better ship than the Siberia for fish transportation, and Captain McKay considers the Parthia as good.

I regard the season as not only bad for transportation, but also for planting, as the fish being turned loose in midwinter had no chance to gradually work into warmer water, which is at greater distance from Boston than any part of England, and the sole swims slowly and apparently laboriously. I have only seen them in aquaria where they are usually on the bottom and occasionally start with a leech-like motion for a short distance and settle down again, not seeming to possess the power of elevating their heads and darting as the flounder does. On the arrival of the tugboat I received a letter of introduction to Mr. C. B. Simmons, collector of customs for the port of Boston, who had so kindly offered to Professor Baird the use of the revenue-cutter to deposit the fish, should they arrive; this I, of course, did not use. The letter of instructions, also received at the same time, directed the fish to be planted "at some point off Nahant," and it is worthy of note that this locality was selected some two hours before getting the letter. I would much prefer soles that had been fed in captivity a month, to any recently captured, if the attempt was again made.

XVIII.—HOW CAN THE CULTIVATION OF THE OYSTER, ESPECIALLY ON THE GERMAN COASTS, BE MADE PERMANENTLY PROFITABLE?*

By Dr. KARL MÖBIUS.

The first condition of successful oyster cultivation on our coasts is a knowledge of the character of our natural oyster-beds. The majority and the best of them are near the islands of Sylt, Amrum, and Föhr. At the northern boundary of our oyster territory, near the island of Röm, and at its southern boundary, near the islands of Pellworn and Nordstrand, not far from the city of Husum, there are but few and small beds. Farther south, near the mouths of the Eider and the Elbe, there are none.

As the oyster-beds share the character of that portion of the sea in which they are located, it is necessary to cast a glance at the character of the Schleswig-Holstein Archipelago.

Compared with the open German Ocean it is a shallow sea. In the whole southern portion of the open German Ocean between Germany, Holland, and England the average depth varies from 35 to 45 meters. In the Schleswig-Holstein Archipelago no such depth is found. The greatest depth of the channels by which it is connected with the open sea averages 15 to 20 meters. The bottom of the archipelago, therefore, rises like a plateau above the deeper ground of the German Ocean. The plateau is intersected by valleys of varying depth and breadth. When the tide is in, the plateau is entirely covered with water, but when the tide is out, large spaces are dry; and these are called "*Watten*," from which this whole sea is also called the "*Watten Sea*."

When the tide goes out, the water flows through these valleys (called "deeps" by the sailors) both in a northerly and a southerly direction into the open German Ocean, until the tide when it comes in, which occurs twice a day from two sides, makes the water flow back. It rises and the valleys can no longer contain the water. It overflows the banks and inundates the "*Watten*" to such an extent that small vessels can sail over the same place where a few hours ago men could walk and drive wagons. For at high tide the water in the "*Watten Sea*" stands 6 feet higher in the north and 9 feet higher in the south than when the tide is low. The current of the water is therefore in

---

* *Address made at the meeting of the German Fishery Association at Berlin, March* 16, 1876, *by Dr. Karl Möbius, of Kiel.* [From Circular No. 3 of the Deutsche Fischerei-Verein, Berlin, March 21, 1877.] Translated by Herman Jacobson.

many places as rapid as the Rhine near Bonn, its rapidity being $1\frac{1}{2}$ to 2 meters a second.

The bottom of this turbulent ocean is mainly composed of quartz-sand. Farther away from the strong currents the so-called "*schlick*" is deposited a clayey mud containing organic matter; this is the case at many points of the eastern coast of Sylt and on the coast of the mainland. On the slopes between the "*Watten*" and the deep channels the bottom is for great distances covered with coarse gravel, small and large stones, and shells. In such places we find, besides many other marine animals, colonies of oysters, so-called oyster-beds. As the water is full of little floating particles of clayey mud, these oyster-beds cannot be seen; their location, however, has been known to the fishers for centuries; and they find them by steering their vessels toward high points of the coast and of the islands. The oysters are caught with drag-nets, consisting of an iron frame from which depends a bag composed of iron rings and coarse yarn, with an opening measuring about 1 meter. The whole net weighs about 60 pounds. It is generally drawn along for 5 to 7 minutes; then two or three men draw it up and throw its contents on the deck of the vessel. This consists of old oyster-shells, different animals and plants, and live oysters, which are picked out, freed from all animal or vegetable matter adhering to the shells, and then shipped to the markets.

In no part of the "*Watten Sea*" do the oysters lie on rocky bottom. The best bottom for them is that which is composed of old oyster-shells. It is an erroneous idea that the oysters stick to the bottom of the sea, or that they lie close together or in layers. In good Schleswig-Holstein oyster-beds the net has to be drawn over a space of 1 to 3 meters square and even larger in order to get a single full-sized oyster.

The number of our oyster-beds is 47, and their extent varies very much. The largest extends one-half German mile (about $2\frac{1}{4}$ English miles) in length. Most of them, however, are not so long, and only a few hundred feet broad. Although all the beds are located within a territory 10 German miles long and 3 German miles broad, the quality of the oysters varies very much. If all the 47 beds were put together, they would not cover the hundredth part of that portion of the "*Watten Sea*" which always remains under water. What is the cause of this? Is there a lack of young oysters to occupy all the vacant spaces between the beds? I cannot suppose that this is the case, and my reasons are the following:

The total number of full-grown oysters in our beds may be about 5,000,000. According to investigations made by me in 1869, at least 44 per cent. of all the full-grown oysters produce young ones; and as every full-grown, pregnant oyster produces at least 1,000,000 young ones, the number of young oysters produced during the breeding season, which generally lasts from June till August, would be 2,200,000,000,000, sufficient to make the whole "*Watten Sea*" one continuous oyster-bed;

for if this number of oysters is spread over a space 30 German miles square, there would be 1,332 to every square meter.*

If, in spite of this, the oyster-beds have not extended over the whole "*Watten Sea*," the reason cannot be that the quality of the water is less favorable to the oyster in some places than in others; for throughout this whole sea it has the same quantity of salt, viz, 3 to 3.2 per cent. The temperature is likewise the same everywhere, for both in the oyster-beds and in other places it varies in the course of the year 20° above to 2° below zero (Celsius). Want of food cannot be the cause why the oyster-beds have for centuries kept within certain limits, for the water of this sea is full of microscopic plants and animals and decaying organic matter, all of which might serve as food for the oysters. The only remaining natural cause which could hinder the oyster-beds from extending and increasing is the unfavorable character of the bottom in the greater portion of the "*Watten Sea.*" *Oysters do not flourish on bottom consisting of quicksand or deposits of clayey mud mixed with organic matter.* And one of the two is found in the greater portion of the bottom of the "*Watten Sea.*" The size and number of those places where, in spite of the tide, the bottom remains firm and free from deposits, is very limited, and only in these limited spaces oyster-beds can be formed. In order to explain this I must say a few words on the structure and development of the oyster.

The mother-oyster does not lay her eggs immediately in the water, but keeps them in the so-called beard (the gills of the oyster) until the little creatures are able to swim. These young oysters, of a bluish color and 0.15 to 0.18^{mm} long, swarm about in the water and finally settle on the bottom.

If this young oyster gets to a place where there are clean stones or shells on which it can grow, there is a prospect of its reaching its full size, but if it gets on quicksands or muddy deposits, it is lost; for, as it has no feet, like some other shell-fish, it cannot work itself out of the sand and clay.

Most of these young oysters doubtless die very soon, because they find no clean places on which to grow. This circumstance has led to the artificial cultivation of the oyster in France, whose author is Professor Coste, of Paris. In the spring of 1858 he distributed in the bay of St. Brieux shells and heavy fagots over a space of 1,000 hectares (1 hectare = 2.4711 acres), and on these spread 3,000,000 mother-oysters. In autumn all the fagots were of course covered with young oysters; for, if these oysters were as fruitful as the Holstein oysters, there were 132,000 young oysters to every square meter. The boldest expectations were exceeded. It was thought that now the means had been found to surround every French coast with oyster-beds, and people already com-

*In a work on "The Oyster and its Cultivation," which I intend to publish very soon, I shall give the data on which these figures are based. I feel convinced that they are not exaggerated, but are rather below the actual figures.

menced to calculate, according to the price which oysters had at that time, how many millions of francs would be yielded by this harvest of the sea. Capitalists went into partnership with fishermen and started artificial oyster-beds; but the rich harvest of marketable oysters failed everywhere, because the greater portion of the young oysters had been destroyed by quicksand or clayey deposit, by want of food, or by enemies.

At present the catching and raising of young oysters is only successfully carried on in a few places on the French coast which are favorable for this cultivation; on a large scale in the bay of Arcachon, south of Bordeaux. In this bay the young oysters produced by mother-oysters on natural beds are caught on fagots, separated from these in October, and then placed in boxes, and finally in artificial ponds. In these they are protected against their enemies by wires or nets. Once or twice every year they are placed in other clean ponds, and care is taken that both during the coldest and the warmest season they are covered by at least 20 centimeters of water.

By this improved method 196,000,000 marketable oysters have, in 1875-'76, been raised in the bay of Arcachon, and the price of oysters fell in consequence. While in 1873 a thousand oysters cost 43 francs, they could be bought for 25 francs in 1876. Compared with the considerable expense of starting and running the oyster establishments, this price is so low that only those oyster-raisers made money who, as I know from good authority, worked with their own hands and were assisted by their families.

Who would not like to see this improved method of raising oysters, in spite of its expense, introduced on our coasts? I will therefore endeavor to answer the question whether the essential conditions of its success are found in the German seas.

The saltness of the water, the food, the currents, and the character of the bottom would make our "*Watten Sea*" as suitable a place for oyster cultivation as the bay of Arcachon; but its tide and temperature are unfavorable. In the bay of Arcachon the usual difference between high and low water is 15 to 16 feet, and, during a storm, only 3 to 4 feet more. On our North Sea coasts the water can rise during a storm twice as much and even more than at the common tide. The force of the water is therefore much greater on our coasts than in the bay of Arcachon. We would, therefore, have to give to our oyster-ponds a much greater power of resistance. But, even if they could resist the strongest floods, they could scarcely protect the oysters against the quicksands and the clayey mud. An experiment made near Norderney, in 1869, has proved this to be true. In the spring of that year a basin 10,000 feet square was constructed on the landward coast of the island; it was inclosed by protecting walls and divided into two smaller basins. In the beginning of June 20,000 full-grown oysters were placed in it, but the young oysters which had been looked for did not make their appearance; starfish and crabs attacked the oysters. In August storm-floods broke

the protecting walls, and the autumnal gales completed the work of destruction, so that soon every trace of the basins had disappeared.

If the open "*Watten Sea*" is not suitable for the construction of oyster-beds, oysters might possibly be cultivated within the dikes which shelter the fertile marshes of the North Sea coasts. For this purpose basins would have to be dug within the dikes and connected with the sea by a canal. Wherever this canal would cut a dike, a sluice would have to be constructed so as to prevent the sea from overflowing during high floods. The oyster-basins could not be constructed near the existing sluices of our marsh-dikes, because these serve to let the fresh water run off from the marshes; the oyster-basins would therefore be filled with fresh water instead of salt water.

Unless oyster-beds could be constructed within a dike, and, without endangering the surrounding country, could be filled with salt water, the oysters would have but a very scanty supply of food, much less at any rate than in the open sea, where, every day, a greater quantity of water containing food runs over every oyster than in a small basin. But the greatest danger for the basin oysters would be frosty weather, because on our coasts the lowest water is during east wind, which, at the same time, brings the greatest cold. At the very time when high water and frequent change of water would be the best means of protecting the oysters from death by freezing, this means could not be employed, and during cold winters many more oysters would die in the basins than in the natural oyster-beds.

Oysters raised artificially would, therefore, with us be a very expensive luxury; and probably they would cost us more than they cost some of the English oyster cultivators. According to an official report by Mr. Blake, inspector of fisheries, every oyster raised artificially near Reculvers, at the mouth of the Thames, cost £50; in Herne Bay, £100; and in some other places, as much as £500!

All investigations which have been made have led to the deplorable result that a profitable cultivation of the oyster according to the French method is impossible on our North Sea coasts. We are, therefore, confined in our activity to the oyster-beds, and we shall have to answer the important question whether it is possible to enlarge the existing oyster-beds and to construct new ones.

Old beds will grow naturally when the movable and clayey bottom near their boundaries becomes firm and pure, which may be occasioned by changes of the direction and force of the currents. In such cases the enlargement of the bed may be accelerated by putting shells on the firm bottom, so as to provide objects to which the young oysters may cling.

In order to construct new oyster-beds we want more extensive portions of the "*Watten Sea*," with a depth of one to four meters, and not liable to change. At my request the men best acquainted with the bottom of the "*Watten Sea*," viz, those men who have to mark the navi-

gable channels with buoys, have last year searched for such firm portions of the bottom on which there are no oysters, but could not find more than eight. There would be a risk to put at once any considerable quantity of mother-oysters in all these places, because as yet it is very doubtful whether they would there find all the conditions for the formation of new beds.

It would be more to the purpose to put, during the month of May, oyster and other shells only in one of these places, and in the beginning of June to distribute a few thousand grown oysters over this prepared bottom. Even if in autumn young oysters were found, the experiment could not yet be considered a perfect success before (besides the mother-oysters) oysters have grown there capable of propagating the species.

I consider it an impossibility to construct oyster-beds in the Baltic. Its water is too cold for oysters, has too little saltness, and is too stagnant, because there is no tide. All attempts in this direction made at the Greifswalder Oie, in the Bay of Kiel, and near the islands of Lolland and Sealand, have proved failures.

Four miles east of Kiel there is a fossil oyster-bed on a hill not far from the shores of the Baltic. Thousands of years ago oysters must, therefore, have lived in the Baltic, when it was connected with the North Sea by broader and deeper channels, and therefore shared its saltness, temperature, and tide. If at the present day oysters could live in the Baltic, they would either not have left it, or they would have immigrated again from the Northern Kattegat, where there are natural oyster-beds. That the oyster will go anywhere where all the conditions for its healthy life are found is proved by their spontaneous immigration into the Limfiord, in the north of Jutland. Till the year 1825 this fiord consisted of a series of brackish lakes, having an outlet into the Kattegat. During the eighteenth century several futile attempts were made to plant oysters in the Limfiord; but after the dike separating the western portion of the Limfiord from the North Sea had been broken by the great flood of February 3, 1825, the water of the fiord grew more salty every year, the animals peculiar to the brackish water disappeared gradually, their place was taken by animals living in the North Sea, and among these oysters were discovered in 1851. Their number increased from year to year; in 1860, 150,000 were caught, and in 1871–'72 more than 7,000,000 were exported to foreign parts. At present one knows ninety-eight places in the Limfiord where oysters live.

We must therefore give up our fine hopes to see all our coasts fringed with oyster-beds and to see oysters as an article of food on every table. Both the nature of our seas and the nature of the oyster drive us to this conclusion. It will be particularly hard to understand this for those who share the wide-spread opinion that every egg laid by a full-grown oyster is destined to become an oyster. Those animals have the smallest number of eggs or young ones which shelter and nurse their offspring till they can find their own food. In many lower grades of ani-

mals, to which the oyster belongs, the propagation of the species is secured not by a long period of nursing, but by producing so large a number of young ones that, in spite of all the destructive influences to which they are exposed, a certain number invariably live to grow to maturity. But this remnant of the full-grown offspring of the mother-oyster is, even in the best and most carefully managed beds, so small that I feel convinced no one would credit my statements if I could not prove their correctness by authenticated figures.

The Schleswig-Holstein oyster-beds were, in the year 1587, seized by King Frederick I of Denmark, as property of the crown. Since the beginning of the eighteenth century they were rented, generally for a long number of years. In order to prevent their being exhausted, the government had these beds officially examined from time to time. In the presence of the government officials, the oyster fishers had generally to throw out their nets in three different places in every bed. All the oysters which they caught were separated into three classes: "*Zahlbar gut*," marketable goods; "*jung gut*," young oysters; and "*junger anwachs*," the youngest and scarcely developed oysters. The first class comprised the full-grown oysters. They are at least 9 centimeters long and broad. Most of them are seven to ten years old, some even older, the oldest being, according to my estimate, twenty to thirty years. The second class comprises the half-grown oysters, measuring less than 9 centimeters, and being three to six years old. The third class comprises the smallest oysters, one to two years old. In the official reports it is mentioned how many of the first two classes were taken at every haul. Those of the third class were not counted, but it is merely mentioned whether the quantity taken was large or small.

Between the years 1730 and 1852 all the oyster-beds were examined ten times. In comparing the number of grown and half-grown oysters taken at each of these inspections, we find figures which differ very much from each other, and do not seem to indicate any leading rule or principle. But if from these figures we calculate the proportion of half-grown to full-grown oysters at every inspection, we find the astonishing result that this proportion scarcely varies at all, and if we take the average of these ten inspections, we find to every 1,000 full-grown oysters not more than 421 half-grown ones. The half-grown oysters make the total of grown young ones produced by the full-grown oysters of a bed. How small does this number, 421, seem if compared with the immense number of young produced by a full-grown oyster! I said before that in our beds at least 44 per cent. of all full-grown oysters lay eggs. Of 1,000 oysters, 440 would, therefore, lay eggs, and as every full-grown oyster lays at least 1,000,000 eggs, we would, of 1,000 full-grown oysters in one bed, get at least 440,000,000 young oysters; but as, on an average, only 421 grow to maturity, we lose, for every Holstein oyster which comes on the table, 1,045,000 young oysters. By sacrificing this immense number of young oysters, nature secures a mature age to a few.

In 1870 a small oyster-bed was discovered in the mouth of the Thames, northeast of Whitstable, measuring 60 feet in length and 20 feet in breadth. Forty-eight hours after it had been discovered 75 vessels were on the spot fishing oysters. Most of those which they caught were not fully grown, but there were not more than 9 to 10 young oysters of different ages to every full-grown oyster. This fact goes to show that I was correct in proving that, compared with the immense number of young oysters produced, but few reach maturity.

To 1,000 human beings we count 6.26 births, and of 1,000 human beings born 554 reach the age of twenty or more years. The productiveness of the oyster is, therefore, 7,000,000 times larger than that of man, but the capacity to mature is 579,000 times greater in man than in the oyster.

From the steady proportion between the full-grown and half-grown oyster of one bed, we find that a certain space requires two to three years to replace 1,000 oysters that have been caught. It follows from this that even the most productive beds, if fished every year, must gradually grow less productive and finally be totally exhausted. Unmistakable proofs of this fact are found in the official reports on the oyster fisheries of France and England. Near Falmouth 700 men, with 300 boats, used to carry on very profitable oyster fisheries, as long as the old prohibition laws were in force. Since 1866, when these laws became a dead letter, the beds have decreased in productiveness, so that at present only 40 men, with less than 40 boats, are engaged in the oyster-fishery, each boat catching, on an average, no more than 60 to 100 oysters per day.

On the rich oyster-beds of Cancale, on the coast of Normandy, 62,000,000 oysters were, on an average, caught every year from 1842 to 1849. After the year 1849 the number decreased from year to year. In 1859 it was 16,000,000; in 1861, 9,000,000; in 1863, 2,090,000, and in 1865, only 1,100,000.

The official reports on the inspection of our oyster-beds have furnished the key for the solution of this problem.

If the oysters on the coast of Normandy have the same capacity to mature as the Schleswig-Holstein oysters, from 1841 only 40 per cent. of the 62,000,000 full-grown oysters near Cancale ought to have been annually taken away in order to preserve for the beds the capacity to mature which was necessary to secure maturity to 24,000,000 to 25,000,000 young oysters. This excessive oyster-fishing in France and England is contemporaneous with the age of railroads, and grows almost in the same proportion as the railroads extend.

Before the age of railroads the inhabitants of the sea-coast were the principal oyster-eaters. September 21, 1740, the first 100 fresh oysters were in Hamburg sold for 1.42 marks (present German money) apiece (about 37 cents); on the same day 900 were sold for 1.20 marks the hundred; then 3,400 for 60 pfennige a hundred, and finally 10,800 for 30 pfennige a hundred.

As scarcely any oysters were shipped farther inland, it was necessary that the price should fall rapidly if the oysters were not to spoil. And this rapid fall in the price of oysters preserved the beds from being exhausted.

But as soon as the railroads brought fresh oysters to the inland cities the number of oyster-eaters increased, and thus the demand for oysters likewise increased from year to year in spite of the rapid rise in the price. I think that this has caused a more reckless fishing of oysters since 1852; and this conviction is strengthened by the fact that at the inspection of 1869 there were only 282 half-grown oysters to 1,000 full-grown ones, instead of 421, as in former years, and during the five inspections held, 1872 to 1876, this number had decreased to an average of 107.

Many Englishmen who are theoretically and practically well versed in everything which concerns the oyster think that the rapid decrease of the number of oysters is not caused by too reckless fishing, but try to explain the fact by a series of years unfavorable to the breeding of the oyster. According to their statements no considerable number of oysters has been bred since 1857–'59. This may be true with regard to some oyster-beds, but it has no influence on the general oyster-trade on the western coasts of Europe, as this is not dependent on particularly favorable summers, but on the average climate. And, according to observations made by the Paris Observatory, since 1806 this average climate has remained the same during this century, which has witnessed the total depletion of some West European oyster-beds.

If the average profit from a bed of oysters is to remain permanently the same, a sufficient number of mother-oysters must be left on it, so as not to diminish the capacity of maturing. For if all the destructive causes continue in the same degree, the capacity of maturing must decrease in the same proportion as the number of oysters capable of propagating is diminished.

If an oyster-bed is to retain its usual capacity of maturing, even when its productiveness is diminished, the causes which destroy young oysters must be diminished. This can be done:

1. By increasing the number of places to which young oysters can cling.

2. By diminishing the number of enemies of the oyster.

This can only be done under such favorable natural conditions as in Arcachon and some other places on the French coast, at least on such a scale as to make the profitable cultivation of the oyster possible. As we cannot cultivate it on our coasts, it is our duty to regulate the fishing in our natural oyster-beds in such a manner as to make them produce permanently the highest possible average quantity of oysters. As the annual increase of half-grown oysters is 421 to every 1,000 full-grown oysters, not more than 42 per cent. of these latter ought to be taken from a bed during a year.

It is best only to take the older of the full-grown oysters, in order that the fully matured ones may get as large and as fat as possible, and produce the greatest possible number of young ones before they are brought into the market.

Every oyster-bed where fishing is going on ought to be examined at least every two to three years to ascertain the following points: 1, the numerical proportion between full-grown and half-grown oysters; 2, the density of the oysters; 3, the nature of the bottom, the fauna and flora of the bed; 4, whether the area covered by oysters has been diminished or enlarged, or remained the same.

If movable bottom in the neighborhood of a bed becomes firm, it should be covered with oyster-shells or other objects to which the young oysters may cling.

If a bed has become filled with sand or clayey mud, it ought to be cleaned with oyster-nets or harrows.

Wherever circumstances permit, the enemies of the oyster ought to be kept away from the beds as much as possible.

As not all beds produce oysters of the same fine quality, experiments ought to be made to show whether young, half-grown oysters of an inferior quality will improve in flavor if transplanted to other beds having better oysters. This ought, however, not to be done systematically if the productiveness of the beds seems to suffer by it. The sea-water which daily flows over the bed contains only a certain limited amount of nutritious matter, and there is a possibility of this being exhausted. If the number of oysters produced by a bed is doubled by introducing oysters from other beds, only half the quantity of food comes to each oyster, and its growth is retarded.

It is fortunate that the Schleswig-Holstein oyster-beds are the property of the state. If everybody could fish there, they would soon be exhausted. If they are to remain a permanent source of profit to the whole population of the state and of special profit to the inhabitants of the coast, the quantity of oysters to be taken annually ought not to be determined by the price of the oysters, but solely by the annual increase. Oyster-beds ought to be worked on exactly the same principles as the state forests, with a view to the welfare of the present and future population of the whole state.

APPENDIX C.

MISCELLANEOUS.

XIX.—EXPERIMENTS UPON THE TIME OF EXPOSURE REQUIRED FOR ACCURATE OBSERVATIONS WITH THE CASELLA-MILLER DEEP-SEA THERMOMETER.

By Commander L. A. Beardslee, U. S. N.

UNITED STATES STEAMER BLUE-LIGHT,
Noank, Conn., September 1, 1874.

SIR: In compliance with your request that I should examine and compare the thermometers, standards and others, belonging to the United States Fish Commission, I have carried on a series of experiments with them, the results of which I herewith submit to you as one of the results of the summer's work of the Commission.

The instruments delivered by you to me to examine were the following, arranged and numbered according to their sensitiveness as developed during experiments:

No. 1. A mercurial standard, made by L. Casella, of London, No. 7,432, reading from zero up to 120°, on a scale marked on the glass, and twelve inches long, giving ten degrees to the inch; bulb cylindrical, .75 of an inch in length. No mounting; sensitive to the slightest change, and rapid in action.

No. 2. A mercurial standard, No. 16,578, made by James Greene, New York, reading from zero up to 120°, on a scale marked on the glass, and four and four-tenths inches long, giving twenty-seven and two-tenths degrees to an inch; bulb cylindrical, seven-tenths of an inch in length. No mounting; as sensitive as No. 1, and agreeing closely with it.

No. 3. A mercurial standard, no number, made by James Greene, New York, reading from 50° up to 105°, on a scale of six inches, marked upon a metal-back mounting. Very sensitive, but not convenient, on account of limited range.

No. 4. A mercurial standard, no number, made by Tagliabue, of New York, reading from 5° below zero up to 125°, on a scale 7.8 inches long, equal to nearly 16° to an inch; scale marked on a metal-back mounting; bulb spherical, with a brass guard. Moderately sensitive, but slow in action.

No. 5. A United States Navy mercurial thermometer, mounted with metal back and cup guard; spherical bulb; scale marked on back. Moderately sensitive, and fair in action.

No. 6. A Casella-Miller self-registering deep-sea thermometer, No. 15,720.

No. 7. The same, No. 17,017.

No. 8. The same, no number. Bought from James Greene, New York, and marked J. G.

Nos. 1, 2, 3, and 4 agreed closely when in equilibrium. No. 1, as the most easily read, on account of its larger scale, was selected as the standard by which to record the actual temperature. Its action was so rapid that no attempt was made to record it during its rise or fall.

No. 6 was defective in that it had an index error averaging $2\frac{1}{2}°$ to be added. It was, however, sensitive, and had fair action.

No. 7 recorded correctly, or nearly so, when in equilibrium.

No. 8 recorded more slowly, and had an index error of about .5 of a degree subtractive.

Our first experiments were made in a tub, containing about ten inches of water, on the surface of which about three inches of broken ice floated; the instruments were laid flat and read through the water. The necessity of constantly agitating the water caused the broken ice to frequently interfere with the range, and produced delay and inaccuracy, and if the water was not thoroughly mixed by stirring, no accurate results could be obtained, the difference in temperature between a point one-half inch below the ice and at the bottom, six inches deep, amounting to six degrees, when the water was tranquil, and so great was this cause of error that between No. 1 lying flat and No. 4 mounted on a metal back, which raised it over one-half inch above No. 1, there was a difference, due to position, of nearly 1°. A bath-tub was therefore devised, which enabled us to record correctly. This consisted of an ordinary aquarium, twenty inches by twelve and fourteen inches deep. This was divided longitudinally by a screen of wire gauze into two compartments, in one of which, nine inches wide, a bath of sea-water, well filled with broken ice, was put from a frame bar lengthwise, and six inches above the narrow section the thermometers were hung, with their bulbs on the same level in the iced water, but free from all contact with the ice.

The apparatus being placed so that the surface of the mercury was in line with the eye (an important precaution where extreme accuracy is desired), the record was read through the glass side and half-inch of water, which, slight enough to present no obstacle to a clear view, was all-sufficient to protect the delicate instruments from external influences.

METHOD OF EXPERIMENTS.

The standard No. 1 was suspended in the water, which was drawn from over the side of the vessel, and cooled down by ice to the desired temperature. An assistant, with a bucket of hot water, a bucket of finely-broken ice, and a table-spoon, stood ready, after the water had settled to the required temperature, to add at each reading a little hot or cold, as the standard's record, read aloud, indicated two or three tenths below or above the bath we wished, while at the same time, with

a spatula, the water was kept thoroughly stirred up. When we had steadied the temperature, the Casella was taken from its bath of sea-water, plunged quickly in, and read at the end of every twenty seconds, and at the same time the standard, which was so delicate that a breath would affect it, was noted.

Tests Nos. 1 and 3, in water and air, were for the purpose of comparing all the thermometers.

In Nos. 1 and 2 from want of practice, we did not succeed in maintaining a uniform temperature throughout, but, as the effect of the gradual cooling of the water was probably analogous to that experienced in lowering the instrument to a great depth, through a constantly lowering temperature, they may possess a value peculiar to themselves, and are therefore given. As they were taken by the first method, they are not strictly accurate, as the ice frequently prevented recording at the instant, and as large pieces were stirred sometimes nearer and sometimes farther from the bulbs, the bath itself was irregular.

This was particularly manifest when, at the end of ten minutes, more ice was added, and the temperature suddenly lowered over 5°; the sensitive instruments marked it at once, the Casellas more slowly, but at the end of five minutes had experienced a great fall. The inaccuracies in reading are probably in no case over one degree.

Test No. 1.—Bath 53°, lowering to 36° 5′.′

The thermometers having been hung side by side in the open air and shade for one hour and recording as per column were placed in bath.

No.	Start.	End of 5*m.*	Fall.	End of 8*m.*	Fall.	End of 10*m.*	Fall.	End of 15*m.*	Fall.	End of 20*m.*	Fall.	End of 25*m.*	Fall.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1	**64.5**	**53**	**11.5**	**44.5**	**8.5**	**44**	**0.5**	**38.5**	**5.5**	**37.3**	**1.2**	**36.5**	**0.8**
2	64.6	52	12.6	44	8	43.5	0.5	39	4.5	37.2	1.8	36.8	0.4
3													
4	65	53.5	11.5	46.5	7	**43.5**	3	38	5.5	37.3	0.7	36.7	0.6
5	64.3	54	10.3	49.5	4.5	**44**	5.5	38.8	5.2	38	0.8	37	1
6	61.5	56.5	5	52	4.5	48	4	37.5	10.5	**35**	2.5	33.5	1.5
7	64.3	60	4.3	56	4	51.3	4.7	40	11.3	**37.5**	2.5	36.4	1.1
8	**63.8**	60.8	3	56.6	4.2	52.5	4.1	40.5	12	**37.8**	2.5	36.3	1.5

In the above table, as in all others, the correct temperature as shown by No. 1 and the point at which each instrument came to it are printed in Egyptian type. To the record of each instrument is applied its index error, in estimating this point, viz: No. 6, 2°.5 added, and from No. 8, $\frac{1}{2}$° subtracted, and the point within .5 of correct assumed to be so.

Test No. 2.—Bath 40°, lowering to 33°.5.

The standard and three Casellas having been exposed in open air and shade one hour, and recording as per column, were placed in bath.

No.	Start.	End 1m.	Fall.	2m.	Fall.	3m.	Fall.	4m.	Fall.	5m.	Fall.
	°	°	°	°	°	°	°	°	°	°	°
1	**67**	**40**	**27**	**39.5**	**0.5**	**38.5**	**1.0**	**37.5**	**1.0**	**36.2**	**1.3**
6	67	54	13	49	5.0	45.5	3.5	41	4.5	39	2
7	68.5	53.5	15	50.5	3.0	46.6	3.9	43	3.6	41	2
8	68	56.5	11.5	52.5	4.0	48	4.5	44	4	42	2

No.	6m.	Fall.	7m.	Fall.	8m.	Fall.	9m.	Fall.	10m.	Fall.	11m.	12m.
	°	°	°	°	°	°	°	°	°	°	°	°
1	**35**	**1.2**	**34.5**	**0.5**	**34.5**	**0.0**	**34**	**0.5**	**33.6**	**0.4**	**33.5**	**33.5**
6	36.5	2.5	35	1.5	34	1	33	1	32	1	31.5	31
7	38.5	2.5	37.2	1.3	36	1.2	36	1	34	1	32.8	33
8	39.6	2.4	38	1.6	36.8	1.2	36	0.8	35	1	33.5	34

Test No. 3, in rising temperature of air.

After test No. 1, the instruments were thoroughly wiped and transferred to the cabin and hung side by side, bulbs on same line; doors and windows were closed and steam turned on to the heater. No. 3, which had been hanging in cabin was included in the test. About 3 minutes were occupied in the transfer, during which they were in air. Temperature 64°.

No.	Start.	End 5m.	10m.	15m.	20m.	25m.	30m.	35m.	40m.	45m.	50m.	55m.	60m.	65m.	70m.	75m.	80m.	85m.	90m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	**36.5**	**72**	**73**	**73.5**	**74**	**74.5**	**74.3**	**75**	**75.4**	**76.8**	**76.5**	**74.5**	**75.2**	**75**	**76**	**76**	**77**	**77**	**77**
2	36.8	72.5	73.5	73.8	74.8	75	74.6	75.5	75.8	77	76	74.8	75.5	75.8	76.8	76.8	77.3	77.4	77.4
3	....	....	73.5	73.5	74.2	74.8	74.5	75	75.5	77	76.3	74.6	75.5	75.5	76.5	76.8	77.2	77.2	77.4
4	36.7	64	68	70.3	71.5	72.8	73.6	74.5	**75.3**	76.5	77	76.6	76.8	76.8	77.8	78	79	79	79
5	37	61	64.5	67	68.5	70.5	70.5	71.3	72	72.8	74	72.8	72	72	73	73.8	74.5	74.4	74.4
6	33.5	37	40	45	49.5	53.5	56.5	59	61	63	64	65	66	66.5	67	68	68.5	69	69.5
7	36.4	39	42	47	52	57	60	63.5	65	67	68	69.5	70	70.5	71	72	72.5	73	73.3
8	36.3	42	44.8	49	53	56	59	62	64	66	67	69	69.5	70	70	71.2	72	72.5	73.2

At ninety minutes the atmosphere of the cabin was so close that it affected my accuracy in reading, and the experiment was therefore ended. The No. 4 stood with the other standards in forty minutes at 75½°, but then, as the temperature rose, passed them and showed about 2° difference in the balance of the readings. I can assign no cause for this discrepancy, nor say which was the correct record, except that the weight of evidence is in favor of No. 1, with which Nos. 2 and 3 closely agreed. Nos. 5, 6, 7, and 8 at the end were still below the true temperature. This I attribute to the fact that, probably, we had not perfectly dried all crevices in the metal cases, and that we got the *evaporating* point in lieu of the true temperature. At the end of fifty minutes the cabin door was opened for a moment; this produced an instant change, which Nos. 1, 2, 3, and 5 recorded fully. No. 4 fell a little, but the three Casellas seemed to make no change on account of it.

Two hours later, the doors and windows having been opened, and steam turned off, the instruments hanging from the same peg, bulbs on a level, recorded: No. 1, 69°; No. 2, 69°.5; No. 3, 69°.5; No. 4, 70°; No. 5, 69°; No. 6, 63°.5; No. 7, 68°; No. 8, 67°.

Test No. 4.—Bath of sea-water, 65°.

The instruments were transferred from a cold bath, recording as per column, to a bath of sea-water and recorded.

No.	Start.	End 1*m.*	Rise.	2*m.*	Rise.	3*m.*	Rise.	4*m.*	Rise.	5*m.*	Rise.	6*m.*	Rise.	8*m.*	Rise.	9*m.*	Rise.	10*m.*	Rise.	11*m.*	12*m.*
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	51.5	66	14.5	65	1	65	....	65	....	65	....	65	....	65	....	65	....	65	....	65	65
6	49	56	7	58.5	2.5	60	1.5	61	1	61.3	0.3	61.5	0.2	61.6	0.1	61.7	0.1	62	0.3	62.2	62.8
7	51	59.5	8.5	61.5	2	63	1.5	63.5	0.5	63.8	0.3	64	0.2	64.2	0.2	64.5	0.3	64.6	0.1	64.8	64.8
8	51.1	56.5	5.4	58	1.5	59.5	1.5	60	0.5	60.8	0.8	61.5	0.7	62	0.5	62.5	0.5	62.8	0.3	63.	63.4

Nos. 6 and 7 occupied full eleven minutes to get a correct record, although each was within one degree; No. 6 in nine minutes, No. 7 in eight. No. 8 was continued four minutes longer in the bath with no change.

A regular series of baths, each 5° lower than the other, was now begun—the instruments being started from as near to a uniform point as possible. No. 6, having been broken, not included in all.

Test No. 5.—Bath of 65°, starting from 69°.

No.	Start.	20*s.*	40*s.*	1*m.*	Fall.	80*s.*	100*s.*	2*m.*	Fall.	140*s.*	160*s.*	3*m.*	Fall.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1	65	....	....	65	....	....	....	65	....	....	....	65	....
7	69	68	67.5	67	2	66.5	66	65.8	1.2	65.6	65.6	65.5	0.3
8	69	68.5	68	67.8	1.2	67	66.5	66.3	1.5	66	66	66	0.3

Test No. 6.—Bath of 60°.

No.	Start.	20*s.*	40*s.*	1*m.*	Fall.	80*s.*	100*s.*	2*m.*	Fall.	140*s.*	160*s.*	3*m.*	Fall.	200*s.*	220*s.*	4*m.*	Fall.	5*m.*	6*m.*
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	60	....	....	59.5	....	....	....	59.5	....	....	....	59.5	....	....	....	59.5	....	59.8	59.8
7	70.5	68.5	66.5	65	5.5	64	62.8	62	3.0	61.5	61	60.6	1.4	60.2	....	60.1	0.5	59.8	59.8
8	70.5	68.8	67	66	4.5	64.8	64	63.5	2.5	62.8	62.2	61.8	1.7	61.5	61.2	61	0.8	60.5	60

Test No. 7.—Bath of 55°.

No.	Start.	20*s.*	40*s.*	1*m.*	Fall.	80*s.*	100*s.*	2*m.*	Fall.	140*s.*	160*s*	3*m.*	Fall.	200*s.*	220*s.*	4*m.*	Fall.	5*m.*	6*m.*
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	55	....	....	54.6	....	....	....	54.6	....	....	....	54.8	....	....	....	55	....	55.2	55.2
7	71	69.5	66.8	64.5	6.5	62.8	61.3	60.2	4.3	59.2	58.5	58	2.2	57.2	56.8	56.5	1.5	55.5	55
8	71	69.8	67	65	6	63.2	62	60.8	4.2	59.8	59	58.5	2.3	57.8	57.2	56.8	1.7	56	55.5

Test No. 8.—Bath of 56° in tub.

No.	Start.	20s.	40s.	1m.	Fall.	80s.	100s.	2m.	Fall.	140s.	160s.	3m.	Fall.	200s.	220s.	4m.	Fall.	5m.	6m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	**56**	......	......	**56**	......	......	......	**56**	......	......	......	**56**	......	......	......	**56**	......	**56**	**56**
6	63	60.5	59	58	5	56.5	56	55.5	2.5	54.8	54.5	54	1.5	54	53.8	53.8	......	......	......
7	65	63.5	62	60.5	4.5	59.5	59	58	1.5	57.6	57	56.8	1.2	56.8	56.5	56.2	......	......	......
8	66	64	63	62	4	60	59.5	59	3.0	58.5	58	57.5	1.5	57	56.8	56.5	......	......	......

Test No. 9.—Bath of 55°, in tub.

No.	Start.	20s.	40s.	1m.	Fall.	80s.	100s.	2m.	Fall.	140s.	160s.	3m.	Fall.	200s.	220s.	4m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	**65**	......	......	**55**	......	......	......	**55**	......	......	......	**55**	......	......	......	**55.4**
6	62.3	60	58	57	5.3	56	55	58.8	2.2	54	53.8	53.5	1.3	53.2	53	**53**
7	64.8	62.5	60	59.5	5.3	58.6	57.8	57.5	2.0	56.8	56.5	56	1.5	55.8	**55.5**	55.2
8	63.4	62.5	61	60	3.4	59.4	58.8	58	2.0	57.2	57	56.5	1.5	56	**55.8**	55.8

Test No. 10.—Bath of 51°, in tub.

No.	Start.	20s.	40s.	1m.	Fall.	80s.	100s.	2m.	Fall.	3m.	Fall.	4m.	Fall.	5m.	Fall.	6m.	Fall.	7m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	**65.5**	**53**	**51**	**50.5**	**15**	**50.5**	......	**50.5**	......	**50.5**	......	**51**	......	**51.2**	......		......	**51.5**
6	64	62	58	57	7	56	55	54	3	52	2	51	1	49.8	1.2	49.5	0.3	**49**
7	66.5	64	61.5	59.5	7	58	57	56	3.5	54	2	53	1	51.8	1.2	**51**	0.8	......
8	66	64.4	62	60.8	5.2	59.2	58.5	57.2	3.6	55	2.2	53.5	1.5	52.2	1.3	**51.5**	0.7	......

Test No. 11.—Bath of 50°.5, in tub.

No.	Start.	20s.	40s.	1m.	Fall.	80s.	100s.	2m.	Fall.	140s.	160s.	3m.	Fall.	4m.	Fall.	5m.	6m.	7m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	**66**	**54**	**50.5**	**50.5**	......	......	......	......	......	......	......	......	......	......	......	**51**	**50.2**	**50.2**
6	63	60.5	58	56.5	6.5	54	53	52.5	4	52	51.5	51	1.5	50	1	49.8	49	**48.2**
7	65	63	60.5	58	7	56.5	55.5	54.5	3.5	54	53.5	53.2	1.3	52.5	0.7	52	51.5	**51**
8	66	63	61	59	7	57.5	57	56	3	55.2	55	51	2	53.8	0.2	52.4	51.2	**50.8**

Test No. 12.—Bath of 50°, in aquarium.

No.	Start.	20s.	40s.	1m.	Fall.	80s.	100s.	2m.	Fall.	140s.	160s.	3m.	Fall.	4m.	Fall.	5m.	6m.	7m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	**70**	**55**	**50.3**	**49**	......	**49**	......	**49.5**	......	**50**	......	......	......	**50.4**	......	**50**	**50.4**	**50.4**
7	70	67.5	64	61	9	59	57.5	56.5	4.5	55.5	54.8	54	2.5	52.6	1.4	51.6	51	50.5
8	70	68.5	66.5	62	8	61.5	59.8	58.5	3.5	57.5	56.2	55	3.5	53.4	1.6	52.2	51.5	**51**

Test No. 13.—Bath, average, 45°, in aquarium.

No.	Start.	20s.	40s.	1m.	Fall.	80s.	100s.	2m.	Fall.	3m.	Fall.	4m.	Fall.	5m.	Fall.	6m.	7m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	**44**	......	......	......	......	**44.5**	......	......	......	**45**	......	**45**	......	**44.8**	......	**45.2**	**45**
7	70	65.5	62.5	59	11	56.5	54.5	52.5	6.5	49	3.5	47.2	1.8	46.5	0.7	45.8	**45.2**
8	70	67	64.2	61.5	8.5	58.5	56.5	54	7.5	50.5	3.5	48.5	2	47	1.5	46.2	**45.6**

Test No. 14.—*Bath, average,* 44°.3, *in tub.*

No.	Start.	20s.	40s.	1m.	Fall.	2m.	Fall.	3m.	Fall.	4m.	Fall.	5m.	Fall.	6m.	7m.	8m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	66.5	48	45	45	21.5	44	......	43.6	......	44	......	44	......	44.4	44.5	44.5
6	63.5	60	57	54.5	9.0	49	5.5	47	2.0	44.8	2.2	43.5	1.3	43	42.5	42.5
7	66.5	62	59	56.5	10.0	51.5	5.0	49	2.5	47	2	46.5	0.5	45.8	45	44.8
8	66	64	61	58.3	7.7	53	5.3	50.5	2.5	48.2	2.3	46.8	1.4	45.8	45	44.8

Test No. 15.—*Bath* 43°, *in tub, noted by* 10-*second intervals for* 5 *minutes.*

No.	Start.	10s.	20s.	30s.	40s.	50s.	60s.	Fall.	20s.	40s.	2m.	Fall.	3m.	Fall.	4m.	Fall.	5m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	43.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	43
6	63.5	60	58	55.5	54	53	51.5	12.0	49	47.5	46	5.5	42.6	3.4	41.2	1.4	41
7	65	63.5	61.5	60	58.5	57	55.6	9.4	53.5	51.8	50.5	5.1	47.5	3	45.8	1.7	45
8	65.5	64	63	61	60	58.6	57.8	7.7	55	53	51.5	6.3	47.8	3.7	46	1.8	45

Test No. 16.—*Bath of* 40°, *in aquarium.*

No.	Start.	20s.	40s.	1m.	Fall.	80s.	100s.	2m.	Fall.	3m.	Fall.	4m.	Fall.	5m.	Fall.	6m.	7m.	9m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	40	.....	.....	.....	.....	.....	.....	40.5	.....	40	.....	40.5	.....	40	.....	40	40	40
7	70	65	60	56	14	53	51	49	7	45.8	2.2	43.5	2.3	42.6	0.9	41.8	41.2	41
8	70	67	.....	59.5	10.5	56.5	54	52	7.5	47.6	4.4	44.2	3.4	42.8	1.4	42	41.2	40.8

Test No. 17.

(Canceled.)

Test No. 18.—*Bath of* 35°, *in aquarium.*

No.	Start.	20s.	40s.	1m.	Fall.	2m.	Fall.	3m.	Fall.	4m.	5m.	6m.	7m.	8m.	9m.	10m.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	36	......	......	35.5	......	35	......	35	......	35	34.8	35.2	34.8	35	34.8	35
7	70	65.5	59.5	55	15	46	9	51.5	4.5	39	37.5	36.5	35.8	35.5	35.2	35
8	70	67.5	63	59.5	10.5	49	10.5	43.5	5.5	40.5	38.5	37.5	36.6	36	35.8	35.5

Test No. 19.—*Bath of* 35°, *in tub, recorded every* 10 *seconds for* 4 *minutes.*

No.	Start.	10s.	20s.	30s.	40s.	50s.	1m.	70s.	80s.	90s.	100s.	110s.	2m.	130s.	140s.	150s.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
6	63	62	58	55	54	52	50.5	49	48	46.8	45.5	44.8	43.8	42.8	42.2	41.8
7	65.5	62.5	60	58	56	54.2	53	51.6	50.5	49.1	48.5	47.5	46.8	46	45.2	44.8
8	64	63	61	59	57.5	56.5	54.5	53.5	51.5	50.1	49.5	48.6	48	46.8	46.3	45.8

No.	160s.	170s.	3m.	190s.	200s.	210s.	220s.	230s.	4m.	Remarks.
	°	°	°	°	°	°	°	°	°	
1	35	35	35	35	35	35	35	35	35	
6	41.3	40.6	40	39.5	39	38.7	38.3	38	37.7	Fall in 4 minutes, 25°.3.
7	44.1	43.8	43.1	42.7	42.1	41.7	41.1	41	40.8	Fall in 4 minutes, 24°.5.
8	45.1	44.7	44.3	43.8	43.1	42.8	42.2	41.8	41.3	Fall in 4 minutes, 22°.7.

Test No. 20.—*Bath* 31°.

In ice broken to the size of a walnut, with sufficient sea-water to fill interstices; depth enough to cover bulbs.

No.	Start.	1*m.*	Fall.	2*m.*	Fall.	3*m.*	Fall.	4*m.*	Fall.	5*m.*	Fall.	6*m.*	Fall.	6½*m.*	7*m.*	7½*m.*	8*m.*	8½*m.*	9*m.*
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	31	31.2	.....	31	.....	31	.....	31.2	.....	31	.....	31	.....	31	31	31	31.1	31	31
7	57	48.5	8.5	42	6.5	38.5	3.5	36.5	2.0	35.2	1.3	34.3	0.9	33.8	33	32.5	32	32	32
8	57	52	5	45.5	6.5	40.8	4.7	38	2.8	36.2	1.8	35	1.2	34.5	33.8	33.3	33	32.8	32

Test No. 21.

In a large cake of ice auger-holes were bored and the bulbs of the standard and successively the two Casellas, Nos. 7 and 8, were placed in the holes, and then packed firmly with finely scraped ice. No. 1 fell to 32°.5 very quickly, and then, although looked at every 20 seconds, never varied a particle. The ice was in the shade, and the temperature 67°.

No.	Start.	20*s.*	40*s.*	1*m.*	Fall.	80*s.*	100*s.*	2*m.*	Fall.	140*s.*	160*s.*	3*m.*	Fall.	200*s.*
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
7	70	65	59	55	15	52	50	48.5	6.5	46.5	45	43.8	4.7	42.8
8	70	68	63	58	12	54	51	49	9	47.2	46	44.8	4.2	43.8

No.	220*s.*	4*m.*	Fall.	260*s.*	280*s.*	5*m.*	Fall.	320*s.*	340*s.*	6*m.*	Fall.	7*m.*	Fall.	8*m.*
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
7	42	41.2	2.6	40.6	40	39.4	1.8	39	38.4	37.8	1.6	36.8	1.0	35.8
8	42.8	42	2.8	41.3	40.8	40.2	1.8	39.8	39.5	39	1.2	38	1.0	37.2

No.	Fall.	9*m.*	Fall.	10*m.*	Fall.	11*m.*	Fall.	12*m.*	Fall.	13*m.*	Fall.	14*m.*	Fall.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
7	1	35	0.8	34.6	0.4	34.2	0.4	34	0.2	34	....	34	......
8	0.8	36.4	0.8	35.8	0.6	34.8	1.0	34.4	0.4	34.2	0.2	34	......

Test No. 22.

No. 7, from a low temperature, was brought up with warm water, and when at 70°, and rising moderately fast, placed in the ice as before. No. 1 maintaining 32°.5 throughout.

Start.	20*s.*	40*s.*	1*m.*	Fall.	80*s.*	100*s.*	2*m.*	Fall.	140*s.*	160*s.*	3*m.*	Fall.	200*s.*	220*s.*	4*m.*
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
70	69	67.4	65.4	4.6	63.5	62	59.5	5.9	57	55.5	54	5.5	53	52	51.5

Test No. 22—Continued.

Fall.	260s.	280s.	5m.	Fall.	6m.	Fall.	7m.	Fall.	8m.	Fall.	9m.	Fall.	10m.	Fall.
° 2.5	° 50.8	° 49.2	° 48.5	° 3.0	° 47	° 1.5	° 45.5	° 1.5	° 44	° 1.5	° 42.5	° 1.5	° 41	° 1.5

11m.	Fall.	12m.	Fall.	13m.	Fall.	14m.	Fall.	15m.	Fall.	16m.	17m.	18m.	33m.
° 39.5	° 1.5	° 38.4	° 1.1	° 37.5	° 0.9	° 36.5	° 1.0	° 35.8	° 0.7	° 34.6	° 33.8	° 33.5	° 33.5

This test shows the necessity of care that the mercury is neither rising nor falling when the instrument is sent down for temperature.

Test No. 24.

In a mixture of fine ice, salt, and a little sea-water.

No.	Start.	1m.	Fall.	2m.	Fall.	3m.	Fall.	4m.	Fall.	5m.	Fall.	6m.	Fall.	7m.
1	° 22.5	° 24	°	° 18.5	°	° 18.5	°	° 17.5	°	° 16.5	°	° 16.5	°	° 17.5
7	69	47	22	33	14	26	7	22.8	3.2	21	1.8	19.8	1.2	19

No.	Start.	1m.	Fall.	2m.	Fall.	3m.	Fall.	4m.	Fall.	5m.	Fall.	6m.	Fall.	7m.	Fall.	8m.	Fall.	9m.
1	° 21	° 20.5	°	° 19.5	°	° 18	°	° 17	° ...	° 16	°	° 15.5	°	° 16	°	° 16.5	°	° 14
8	69	55	14	48	7	40	8	33	7	27.5	5.5	23	4.5	21.5	1.5	19	2.5	18

Test No. 24 is not accurate, as it was impossible to keep the temperature at all regular, the standard going up and down four or five degrees at a jump as we stirred the mixture in the slightest degree.

From the experiments recorded I drew the following results: First, and most important, that there are but few cases where "five minutes are sufficient for the thermometer to take up the temperature of its position," as described in the manual accompanying the instruments, and that the length of time necessary to procure a correct record depends upon the difference between the temperature as recorded by the instruments when being lowered, and that of the temperature which is to be measured.

The following abstract from tables shows the truth of this:

Number of table.	Number of instrument.	Temperature at start.	Temperature of bath.	Difference.	Time by correct record.	Average.	Remarks.
		°	°	°	*m. s.*	*m. s.*	
5	7	69	65	4	2 20	2 20	Aquarium.
5	8	69	65	4	2 20		
8	6	65.5	56	9.5	3 40		
8	7	65	56	9	3 50	3 50	Tub.
8	8	65.5	56	9.5	4 00		
9	6	64.8	55	9.8	4 00		
9	7	64.8	55	9.8	3 50	3 53	Do.
9	8	63	55	8	3 50		
6	7	70.5	60	10.5	6 00	6 00	Aquarium.
6	8	70.5	60	10.5	6 00		
10	6	66.5	51	15.5	7 00		
10	7	66.5	51	15.5	6 00	6 20	Tub.
10	8	66	51	15	6 00		
11	6	65.5	50.5	15	7^{m} to 8^{m}		Tub out 5^{m} at 7^{m}.
11	7	65	50.5	14.5	7^{m} to 8^{m}	7^{m} to 8^{m}	Out 8^{m} at 7 m.
11	8	66	50.5	15.5	7 00		
7	7	71	55	16	7 00	7 00	Aquarium.
7	8	71	55	16	7 00		
12	7	70	50	20	7 00	7 00	Do.
12	8	69.5	50	19.5	7 00		
20	7	57	31	26	Over 9^{m}	Over 9^{m}	At 9^{m} 1° out.
20	8	57	31	26	9^{m} to 10^{m}	9^{m} to 10^{m}	At 9^{m} ½° out.
15	6	66	43	23	5^{m} to 6^{m}	....	Tub.
15	7	65	43	22	5 00	....	At 5^{m} lacked 2°.
15	8	65.5	43	22.5	5 00	....	At 5^{m} lacked 1½°.
16	7	70	40	30	9 00	....	Aquarium; at 9^{m} lacked 1°.
16	8	70	40	30	9 00	....	Aquarium.
19	6	65.5	35	30.5	....	....	At 4^{m} lacked 5°.2
19	7	65.5	35	30.5	....	....	At 4^{m} lacked 5°.8 } 5^{m} to 6^{m}.
19	8	64	35	29	....	....	At 4^{m} lacked 5°.8
18	7	70	35	35	10 00	10 00	Aquarium.
18	8	70	35	35	10 00		
2	6	69.5	33.5	36.5	12 00		
2	7	68.5	33.5	35	10^{m} to 11^{m}	11^{m} to 12^{m}	
2	8	67.5	33.5	34	12 00		
21	7	70	32.5	37.5	12 00	12 05	Still lacking 1°.
21	8	70	32.5	37.5	13 00		Still lacking 1°.
21	7	70	32.5	37.5	18 00	....	1° lacking and remained steady 15^{m} longer.
23	7	69	17.5	51.5	7 00	....	Lacking 2° } Not very accurate.
23	8	69	14	55	9 00	....	Lacking 4°

Thus, when the difference in temperature is less than 10°, "five minutes are sufficient"; but as the differences increase, so does the time necessary to produce an equilibrium increase. The third experiment in Table 21 points to the necessity of having the mercury perfectly at rest when about to use the instrument.

An experiment was tried to ascertain the effect, if any, of the sun shining on the stems of the thermometers, the temperature in the sun being 71°; four thermometers with bulbs level in a bath were recorded, and the instruments were entirely immersed, with following results:

No. 1, 9 inches exposed, stood 36°.

No. 2, 4 inches exposed, stood 36°.5.

No. 4, 6 inches exposed, stood 36°.

No. 5, 6 inches exposed, stood 36°.5.

Entirely immersed and read in two minutes they stood: No. 1, 36°.2; No. 2, 36°; No. 4, 36°; No. 5, 36°.5. So that no appreciable error arises from this cause.

Experiments on difference of temperature, in a bath of ice-water not agitated.

No. 1.

No. 1, bulb immersed in contact with ice stood 33°, lowered to 100° stood 39°.

No. 2, bulb immersed in contact with ice stood 33°.2, lowered to 100° stood 36°.

No. 4, bulb immersed in contact with ice stood 33°, lowered to 100° stood 37°.

No. 5, bulb immersed in contact with ice stood 33°.4, lowered to 100° stood 36°.

The differences arising from differences in length of stem causing the bulbs to reach different strata.

Experiment No. 2.

No. 1 and No. 2, lying flat on bottom of tub, with 6 inches of water, 3 inches of broken ice, recorded 42°.5. No. 2 was raised with pincers 2 inches, and fell to 40°.

In addition to printed instructions I would respectfully suggest the following:

1. Keep thermometer at uniform temperature before and between lowerings.

2. Have two snaps on the line above the lead, to prevent delay in bending on.

3. Set and note indexes.

4. Note time of reaching lowest depth, and be sure and keep the instrument at its depth over *ten* minutes, unless previous lowerings have taught that the difference between surface and bottom temperatures is less than requires this time.

5. Do not count *as down* the time wasted if the ship be dragging or drifting and the line trailing out at an angle.

6. In reading hold the instrument *perpendicular*, with the bottom of the index on a level with the eye.

7. On registering, note time and tides.

If the mercury becomes badly disintegrated, and swinging and tapping are of no avail, I have succeeded in getting the thermometer to rights by this method:

No. 15,720 was found damaged; on the hot side the mercury was in four parts, one bit 5° in length, separated from the rest by a space of 10°, and nearly as bad on the cold side. Every other means failing, I placed it bulb up in the salinometer pot; having removed the ebonite guard and turned on steam, the mercury mounted on the hot side and formed a sphere at the lower part of the bulb, until nearly all coalesced, leaving still a columnar portion in the tube. I removed it from the sali-

nometer, and in a few moments the column dropped away from the sphere. This occurred twice, when I concluded that it must cool more slowly, so left it in the boiling water, to cool with it. This produced the desired result, and the hot side became perfectly restored. On the cold side I substituted a mixture of ice and salt, in which I placed the bulb, and with an ordinary cologne spray-bottle, substituting sulphuric ether, threw a spray on the bulb, which acted as did the steam. I was compelled to leave the instrument to warm gradually in a vessel of ice-water, and in an hour had it in good working order.

I send herewith a set of diagrams of the curves produced by the different baths tabulated, and am,

Very respectfully,

L. A. BEARDSLEE,
Commander, United States Navy.

Prof. S. F. BAIRD,
United States Fish Commissioner.

To ascertain the correctness of the standard used in the foregoing experiments, it was tested in the apparatus provided by the Signal Corps for testing thermometers—simply a tin can with a perforated tin false bottom about midway of its height to permit the leakage from the melted ice to escape.

A thermometer manufactured by Tagliabue for the Commission, with cylindrical bulb $1\frac{1}{4}$ inches long and $\frac{5}{16}$ in diameter, graduated from 30° to 140°, on a scale of $8\frac{5}{8}$ inches, was compared at the same time. The bulbs were immersed and packed snug in pounded ice. The Tagliabue recorded 31°.6, and the standard 32°.05. The experiment was repeated with the same result.

Respectfully,

L. A. BEARDSLEE,
Commander.

WOOD'S HOLL, *September* 23, 1875.

An additional set of tests were made with the Cassella-Miller thermometer in use this summer at Wood's Hole (No. 1,844). They were made with the utmost accuracy possible, with the same standard in use last summer, and the aquarium. They have developed the reason of the anomalous action of the thermometers in ice.

In test No. 1, in ice, the instrument was placed on its back in a trench cut in the ice, and the bulbs covered with pounded ice. The mercury corresponded in its action very closely to the action of a bath of 50° until it reached that point.

In test No. 2 the upper portion of the ebonite guard was removed, thus letting the crushed ice come into immediate contact with the upper

portion of bulbs. This induced quicker action, but still slower than a bath of 35°; and at last, as in former cases, the mercury apparently ceased to fall at 35°.

This experiment is put in simply for the purpose of guarding other experimenters against the mistake.

The standard, as in last year's tests, did not vary from 32°.05.

Respectfully,

L. A. BEARDSLEE,
Commander, United States Navy.

Experiments with Casella-Miller, No. 1844.

Time int.	Bath, 60°.		Bath, 55°.		Bath, 50°.		Bath, 45°.		Bath, 40°.		Bath, 35°.		Ice-bath, 32½°.		Ice-bath, 32½°.	
	Standard.	Casella-Miller.	Standard.	Casella-Miller.	Standard.	Casella-Miller.	Standard.	Casella-Miller.	Standard.	Casella-Miller.	Standard.	Casella-Miller.	Standard.	Casella-Miller.	Standard.	Casella-Miller.
m. s.	°	°	°	°	•	°	°	°	°	°	°	°	°	°	°	°
0 00	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
0 20	60.0	68.2	55.0	67.5	50.0	68.0	45.0	67.5	40.0	66.5	35.0	64.5	38.0	67.5	32.5	66.0
0 40	60.0	67.5	55.0	64.5	50.0	65.0	45.0	64.5	40.1	63.1	34.6	58.5	32.5	65.0	32.5	61.2
1 00	60.0	66.5	55.0	62.5	50.2	63.0	45.0	62.0	40.2	59.8	34.6	54.5	32.5	63.5	32.5	57.5
1 20	60.0	66.0	55.0	60.5	50.2	61.0	45.0	59.5	40.2	56.9	34.6	50.0	32.5	61.8	32.5	54.0
1 40	60.0	65.0	55.0	59.2	50.5	59.5	45.0	57.8	40.2	54.5	34.6	48.0	32.5	60.2	32.5	52.0
2 00	60.0	64.5	55.0	58.2	50.2	58.2	45.0	56.0	40.2	52.4	34.6	46.0	32.5	59.0	32.5	50.0
2 20	60.0	64.0	55.0	57.5	50.5	57.0	45.0	55.0	40.0	50.1	35.0	44.5	32.5	58.0	32.5	48.0
2 40	60.0	63.5	55.0	57.0	50.5	56.6	45.5	54.0	40.0	49.4	35.0	43.5	32.5	57.0	32.5	46.8
3 00	60.0	63.0	55.0	56.6	50.5	55.0	45.0	53.0	40.1	48.1	35.0	42.0	32.5	56.2	32.5	46.6
4 00	60.5	62.0	55.2	56.0	50.0	53.2	45.0	50.2	40.2	46.3	35.0	40.5	32.5	54.0	32.5	44.8
5 00	60.5	61.8	55.2	55.6	50.2	52.6	45.0	48.8	40.2	44.0	34.6	37.0	32.5	52.0	32.5	40.0
6 00	60.5	61.5	55.0	55.2	50.4	52.2	45.0	47.5	40.2	42.2	34.6	35.5	32.5	50.5	32.5	38.8
7 00	60.5	61.2	55.0	55.0	50.0	51.8	45.0	47.0	40.0	41.8	34.8	35.0	32.5	49.0	32.5	37.5
8 00	60.5	61.0	55.0	55.0	50.0	51.2	45.0	46.0	39.8	41.2	34.5	35.0	32.5	47.5	32.5	37.2
9 00	60.5	61.0	55.0	55.0	50.2	51.2	44.8	46.0	39.0	40.6	34.5	34.5	32.5	46.2	32.5	36.8
10 00	60.5	61.0	55.0	55.0	50.4	51.0	45.0	45.8	39.5	40.2	34.5	34.5	32.5	45.0	32.5	36.5
11 00	....	....	....	....	50.4	51.0	45.0	45.8	40.0	40.0	34.5	34.5	32.5	43.0	32.5	36.2
12 00	....	....	....	....	....	....	45.0	45.8	40.0	40.0	....	....	32.5	42.2	32.5	36.0
13 00	....	....	....	....	....	....	45.0	45.8	40.0	40.0	....	....	32.5	40.5	32.5	35.4
14 00	....	....	....	....	....	....	....	....	....	....	....	....	32.5	39.5	32.5	35.0
15 00	....	....	....	....	....	....	....	....	....	....	....	....	32.5	38.5	32.5	35.0
20 00	....	....	....	....	....	....	....	....	....	....	....	....	32.5	38.0	32.5	35.0
22 00	....	....	....	....	....	....	....	....	....	....	....	....	32.5	35.6	32.5	35.0
25 00	....	....	....	....	....	....	....	....	....	....	....	....	32.5	35.1	32.5	35.0
														35.2	....	....

XX.—ON ARTIFICIAL REFRIGERATION.

By John Gamgee, London, England.

A.—INTRODUCTION.

Ice, water, and steam, strikingly exemplify the nature of changes, or the different physical states, produced in matter by heat. Ice is a transparent or translucent solid, which melts into water on the addition of 142.66 heat units (Regnault). This water has to be raised from the normal temperature of melting ice, viz, 32° Fahr., to 212° to boil, and every pound converted into steam absorbs 965.7 heat units, without affording thermometric indications of the change. The heat is said to have become latent, but it is lost in molecular motion.

The latent heat of water is higher than that of any other agent, and a great depression of temperature ensues when, from a limited amount of water, vapor promptly rises. Thus, water placed in porous earthenware vessels, which are protected from active surface air-currents, by being placed in shallow pits, freezes in Bengal. Windy nights in summer are unfavorable to the process. It is on still and cloudless nights that active radiation, into open space, favors the crystallization of the water.

Probably with the ice thus formed and the efflorescent salts at hand, the Hindoos first attempted artificial refrigeration. Nitre—the sal petræ of Geber or nitrum of Albertus Magnus—was regarded by the ancients as the *primum frigidum*, the cold element of the earth. It occurred on the borders of the Ganges, in Ceylon, and elsewhere as a natural surface deposit, and, after the rainy season, a crust one-third of an inch in thickness may be gathered from the ground. It is dissolved out of the saltpetre earths, which at Tirhoot, in Bengal, contain from 8 to 9 per cent. of pure potassium nitrate. The mercury descends 18 or 20 degrees if a thermometer be plunged into water simultaneously with nitre. Mixed with ice, a temperature between 5 and 6 degrees below 32° Fahr. is obtained; and we learn, that as early as 1550, the Roman nobles cooled their wines by a mixture of snow and nitre. This frigorific mixture is mentioned by Latinus Tancredus, a professor of medicine in Naples, in his work De Fama et Siti, published in 1607. Villa Franca, a Spaniard, had been credited with the invention, but in all probability the practice was derived from Asia, and popularized by the Portuguese after the first discovery of India. Common salt and ice were adopted by Fahrenheit as the means of obtaining the temperature 0 of his thermom-

eter, and this mixture was widely known to the learned throughout Europe. In Southern Italy it was used for cooling lemonades, and from thence, in the middle of the seventeenth century, sprang the Paris "limonadiers," as well as the preparation of flavored ices and creams, the *gelati* and *sorbetti* of the Italians.

Neapolitans and Swiss Italians have remained preeminent in the management of cafés and the preparation of iced confections. They established themselves early in all the large cities of Europe. It is but recently that an Italian Swiss, by the name of Carlo Gatti, died wealthy and esteemed in London. He was the first practical introducer of ice-creams to the British public. His stall stood forty years since in Hungerford fish-market, and he himself has informed me that, in his early days, he had great difficulty in inducing people to appreciate his *gelati*. He walked about the market with a glassful of ice-cream, and offered spoonfuls to passers-by until they began to acquire the taste for and recognize the wholesome character of cold delicacies. They dreaded them as much as the Brazilians have dreaded ice until recently, being regarded as productive of serious illness. Gatti not only introduced his ice-creams, but did much to popularize the use of ice in London, and to the last he retained a large share of a trade, greatly encouraged by his discrimination and integrity.

In Gatti's early days, Thomas Masters published his Ice Book (1844), which contained some interesting historical data, though the work appeared to advertise patent ice-cream freezers, knife-cleaners, &c. It tended to make the use of ice popular, especially among the rich; and, the growing wants of the metropolis, compelled fishermen to use more and more ice year by year.

The growing wealth of British cities, the facilities for the transport of fish by sea, and a wider appreciation of wholesome fish food, drove the trawlers further and further, year after year, seeking fresh ground and using more ice, the greater the catches and the longer the distance of the fishing-grounds reached from shore. An enterprising firm, of late years organized as a limited liability company (Messrs. Hewett & Co.), established a fleet of steam carrying vessels as their fish business grew.

The steamers are small and carry about 35 tons of ice each, some more, some less. Were they larger, the difficult process, of transferring the fish from the boats, would be attended with even greater danger than it is at present. The steamer is small enough to drop into the trough of the sea with the boat, and the two hug each other, without danger of a crushing collision.

It is in this way that England, and especially London and the fishing-ports of Great Yarmouth and Grimsby, have become the centres of a very extensive and lucrative ice-trade from Norway. In the early days of the British ice-trade a company was formed to import ice from the New World, and "Wenham Lake" ice became the staple and favorite brand.

The distance by sea from America led to enterprising dealers visiting Norway, and Lake Oppegaard was purchased with the privilege of renaming it; the purchasers having made all necessary arrangements for shipments of ice thence to England, the lake has ever since gloried in the name of Wenham. Drobak, Drammen, Christiania, Brockstadt, and other Norwegian ports supply England also.

Mr. Holdsworth,* writing in 1874, said: "It is yet a question whether it will *pay* to apply steam to the actual trawlers, but we had an opportunity in 1872 of observing in an experimental vessel the practical advantage gained by its use, both when fishing and going to and returning from the fishing ground." This at once indicates the probability of using refrigerating machines instead of bulky, costly, and deteriorating processes, and likewise render fishermen altogether independent of ice-crops and ice-merchants.

B.—IMPORTANCE OF FISH-CULTURE IN GREAT BRITAIN.

The favorable conditions of an extensive sea-shore, encirling islands which can be crossed by rail in a few hours, with innumerable streams, to permit the ascent of spawning fish, are most tempting to the fish culturist, and would indicate that a large fish trade could be developed even without ice. The slow progress in the artificial propagation of fish in England is a matter for surprise.

Until this scientific remedy can be applied, the ice-question is a serious one all round the British Isles, and, indeed, the supply of fish, to inland towns, is determined more by the scarcity of ice than the scarcity of fish. The Irish coast would supply large quantities of excellent fish, and many a fishing-village might be made populous and prosperous by an unfailing supply of cheap ice.

C.—ORIGIN OF KNOWLEDGE OF ARTIFICIAL COOLING.

The germ of all the modern improvements in making ice dates back to 1755, when the great Dr. Cullen, Professor of Medicine in the University of Glasgow, attempted to determine whether the solution of certain substances, in spirits of wine, was attended with elevation or lowering of temperature. One of his pupils, entrusted with these experiments, observed that, on withdrawing the thermometer from the alcoholic solution, the mercury fell, and, with the aptitude of an original observer, Cullen tried the pure spirit. By moistening the bulb with a feather and blowing to hasten evaporation, the temperature dropped from 44° to below 32°. He pursued his investigations further, and tried a variety of volatile substances, of which he found the "quick-lime spirit of sal ammoniac" the most powerful. This is a singularly felicitous anticipation of the knowledge we now possess, that no liquid, boiling at low temperatures, absorbs more heat than ammonia.

* Deep-Sea Fishing and Fishing Boats. London, 1874.

In one of his experiments Cullen used nitrous ether, when the heat of the air was 53°. He set the vessel, containing ether, in one a little larger containing water, and placed the two under the receiver of an air-pump. On exhausting the receiver and maintaining the vessels in vacuo for a few minutes, the water in the outer vessel was frozen and the ether recipient coated with a firm and thick crust of ice.

Dr. Cullen explains in his Essay* that he had endeavored to give a notion, of the comparative power of these fluids in producing cold, by the order in which he has set them down, as follows:

1. The quick-lime spirit of sal ammoniac.
2. The æther of Frobenius.
3. The nitrous æther.
4. The volatile tincture of sulphur.
5. Spirits of wine.
6. Spirit of sal ammoniac made with the fixed alkali.
7. Brandy.
8. Wine.
9. Vinegar.
10. Water.
11. Oil of turpentine.
12. Oil of mint.
13. Oil of pimento.

Cullen adds: "From the above enumeration, I imagine it will appear that the power of evaporating fluids in producing cold is nearly according to the degree of volatility in each." . . . . . "From the fact that the cold is made greater by whatever hastens the evaporation, and particularly that the sinking of the thermometer is greater as the air in which the experiment is made is warmer, if dry at the same time, I think we may now conclude that the cold produced is the effect of evaporation."

Dr. Cullen's desire to investigate this subject had been increased by reading M. de Mairan's Dissertation sur la Glace, published in 1749, and he had also been informed of Richmann's researches. Richmann had taken notice of the effect of evaporating fluids in producing cold, but does not impute it to the evaporation alone.

I was fortunate in finding Richmann's papers in the first volume of the Transactions of the St. Petersburg Academy of Sciences for the years 1747 and 1748, in the Congressional Library in Washington, and I subjoin the full titles.† In the same volume I was gratified to dis-

* Of the cold produced by evaporating fluids, and of some other means of producing cold, by Dr. William Cullen (May 1, 1755). Published in Essays and Observations, Physical and Literary. Read before a society in Edinburgh, and published by them. Vol. II. 1756. p. 145.

† G. W. Richmann's papers are four in number: 1st. De quantitate caloris, quæ post miscelam fluidorum certo gradu calidorum oriri debet cogitationes. 2d. Formulæ pro gradu excessus caloris, supra gradum caloris mixti ex nivi et sale ammoniaco, post miscelam duarum massarum aquearum diverso gradu calidarum confirmatio per experimenta. 3d. Inquisitio in legem, secundum quam calor fluidi in vase contenti, certo temporis intervallo, in temperie aeris constantes eadem descrescit vel crescit et detectio eius, simulque thermometrorum perfecte concordantium construendi ratio hinc deducta. 4th. Tentamen legera evaporationis aquæ calidæ in aere frigidori, constantis temperiei definiendi.—Novi Commentarii Academiæ Scientiarum Imperialis Petropolitanæ. Tom. 1, ad annum 1747 ut 1748.

cover a memoir of special value, entitled "Meditationes de Caloris et Frigoris Causa—Auctore Michaele Lomonosow, which has, so far as I am aware, been entirely overlooked by writers on the history of the Theory of Heat. Here I can only state that he recognizes *the sufficient cause of heat as consisting in the motion of matter*, and although for the most part in hot bodies no motion can be perceived by sight, nevertheless it is manifested by its effects. Thus, iron heated almost to ignition, may be quiescent to the eye, but if bodies are brought in contact with it, they melt or resolve themselves to vapors; *that is, their parts are excited by motion.* "Who would deny," says the logical Lomonosow, "that when a violent wind traverses a forest the leaves and boughs of the trees are agitated, although on looking from a great distance no motion could be detected by sight?" I hope elsewhere to publish comments on this remarkable contribution to science, published over fifty years before Benjamin, Count of Rumford, opened his classical Essay on Heat as follows: "Without entering into those abstruse and most difficult investigations respecting the nature of fire which have employed the attention and divided the opinions of speculative philosophers in all ages; without even attempting to determine whether there be such a thing as an igneous fluid or not; whether what we call heat be occasioned by the accumulation or by the increased action of such a fluid, or whether it arises merely from an increased motion in the component particles of the body heated, or of some elastic fluid by which those particles are supposed to be surrounded, and upon which they are supposed to act, or by which they are supposed to be acted upon; in short, without bewildering myself and my reader in this endless labyrinth of darkness and uncertainty," &c., &c. Lomonosow was evidently unknown or neglected, as he has been ever since, so far as I can learn, and it is with infinite satisfaction that I direct attention to a hidden treasure of immense interest to all engaged in the study of physics, and who, in the cause of truth and justice, always desire to give credit where credit is due.

What does he tell us about the nature of cold? He anticipates all that has been said of the *absolute zero*—of the point at which all heat motion ceases. He says: "No celerity of motion can be assumed so extreme that another greater cannot be conceived, since the latter also may justly be referred to calorific motion. Therefore, a supreme and ultimate highest possible grade of heat in respect of motion does not exist. On the other hand, however, the same motion may be diminished to such a degree that finally the body shall be totally at rest, and no further diminution of the motion can follow. Necessarily, therefore, a supreme and ultimate degree of cold will consist in absolute rest of particles." He tells us that "everything which appears to us cold is only less warm than our organs by which we feel." How far-seeing and accurate is the statement that "it is not to be supposed that the congelation of bodies is a criterion of ultimate cold, for metals solidified immediately

after liquefaction are also ice of their kind; yet are they so hot that combustible bodies brought in contact with them are set on fire."

Let us see how he disposes of the *primum frigidum* and *summum frigidum* of other philosophers, of and before his time. He says: "Since the air is always and everywhere observed to be fluid, and therefore (as demonstrated) warm, it follows that all bodies encompassed by the terrestrial atmosphere are warm, although they may appear cold to the senses; *and thus an ultimate degree of cold in our terraqueous globe is not given.*" Can anything be more precise and more philosophical?

Here, indeed, in Michael Lomonosow's splendid memoir, do we discover the doctrine of heat energy and the kinetic theory of gases, traced hitherto, by recent writers, only as far back as 1811 to Avogadro. The history of thermodynamics must now contain a long and deeply-interesting chapter referring to the speculations and close reasoning of Russia's Goethe—a poor fisherman's son, afterward a linguist, rhetorician, poet, dramatist, historian, physicist, and professor of chemistry in the Academy of St. Petersburg—nevertheless forgotten!

D.—DEFINITION OF AN ICE-MACHINE.

I shall only briefly allude now to the laws of heat which control the operations that are to be studied in ice-machines or cold-generators. Cold being only less heat, the entire subject is one of pure thermodynamics, and the labors of Joule, Mayer, Rankine, Clausius, Sir William Thomson, Tait, Tyndall, and others have unfolded the truth of the action of heat-engines, and of the methods by which heat may be abstracted from cold bodies by the energy of heat at higher temperatures. Mr. Alexander Carnegie Kirk, in a paper read in 1874, before the Institution of Civil Engineers in London, defined the mechanical production of cold to be "the removal of heat from a body without the intervention of a colder body, by a continuous circle of operations. Any arrangement for effecting this was merely a heat-engine, whose temperature of absorbing heat was lower than its temperature of ejecting heat, the motive power in this state of things being negative. An air-engine was the type of all refrigerating-machines in which the medium used was incondensable gas. A steam-engine with a surface condenser might be taken as the type of those in which the medium was a vapor or condensable gas. Harrison's ether-machine was the best known of this type."

The analogy with a heat-engine is not altogether simple, since in this the useful work done is the equivalent of heat which disappears during the process, whereas the intervention of motive power to raise heat from water to be frozen to the condenser of an ordinary ice-machine, when abstracted heat is thrown off with a large amount of water going to waste, suggests at once that in an ordinary ice-machine there are two elements to be considered, first, the heat-engine proper, viz, the steam-engine, which operates the second element of the machine, viz, the circulating-pump, dealing with air or liquefiable gases. The same power and the

same fuel will give 1 pound of ice per pound of coal burned if air is being compressed, 3 pounds per pound if ether is used, 5 pounds with sulphurous oxide, and at least from 10 to 15 with anhydrous ammonia. The efficiency of the pump, the varying amount of heat of compression in pumping different gases in relation to the heat transferred from the refrigerator to the condenser, and lastly the temperature of available condensing water tend to produce the most complex conditions which a skilful observer can well be called upon to study.

E.—TYPES OF ICE-MACHINES.

Up to the present time there have been five distinct types of ice-machines in the market.

Firstly. The domestic machines, in which salts are liquefied, as explained elsewhere. Ash's piston freezer and Toselli's frigorific mixture machines belong to this group.

Secondly. The form of apparatus, in which, in addition to the power used, usually by hand, in working an air-pump to favor the evaporation of water to be frozen, we have to calculate the cost of absorbing watery vapor by sulphuric acid in vacuo.

Thirdly. Distillation or absorption machines, in which heat has to separate a chemical, say ammonia, from water, and in which the cooling water has to favor the reabsorption of the ammonia gas heated in the refrigerator.

Fourthly. An air-pump with a so-called regenerator or appliances (whether a second pump or otherwise) to cause work to be done in expansion by the compressed air. This is based on Joule's law, subject to slight deviation, that *to effect change of temperature air must be allowed to expand in such a manner as to develop mechanical power.*

Fifthly. The machines composed of a refrigerator and condenser, with an intervening exhausting and condensing pump driven by an engine.

F.—THERMODYNAMIC LAWS.

It is heat we use as the great agent for producing those changes in the physical state of matter whereby the conversion from a gas to liquid, and from a liquid back to gas is effected. There is a definite relation between heat and work as enunciated in the First Law of thermodynamics.* *Heat and mechanical energy are mutually convertible, a unit of heat corresponding to a certain fixed amount of work, called the mechanical equivalent of heat.* Joule has experimented on the heat produced by the agitation of water, and his latest determinations have proved the correctness of the late Professor Rankine's calculations, viz, that the raising of 1 pound of water 1 degree Fahr., from 39° to 40°, if wholly converted into work, will raise a pound weight through 774.1 feet, sub-

* I would counsel all persons interested in steam-engines, ice-machines, &c., to read The Steam Engine considered as a Heat Engine, by James H. Cotterill. London and New York, Spon, 1878.

ject to a small correction, possibly amounting to $\frac{1}{400}$th, on account of the "thermometric scale of error." Heat and mechanical energy being mutually convertible, quantities of heat may be stated in foot-pounds and quantities of work in thermal units. Taking steam, the total and latent heat of evaporation in thermal units at 401° Fahr. is 1,204.2. This multiplied by the mechanical equivalent of heat, say 774.1 gives 932,050 foot-pounds as expressing the total and latent heat of evaporation at 401°. Moreover, a horse-power of 33,000 foot-pounds per minute is equivalent to $\frac{33000}{774} = 42.48$ thermal units per minute, or 2,548 thermal units per hour. In working examples it is sufficiently near the truth to calculate 42.5 as the heat which disappears by work done, theoretically, per indicated horse-power, or 2,550 thermal units per hour.

The next Law of thermodynamics, the second, on which the art of refrigeration is based, is that "*heat cannot pass from a cold body to a hot one by a purely self-acting process.*" Mr. Cotterill says on this point, "It is easy to see what enormous consequences the denial of this principle would involve in the theory of the steam-engine, for all the heat expended in the boiler which is not transformed into mechanical energy—that is to say, at least five-sixths of the whole amount—appears in the condenser being employed in heating the condensation-water, and if it were possible by some self-acting contrivance to cause that heat to flow from the condenser into the boiler, it is manifest that the said five-sixths of the consumption of heat might be saved. It is certain, however, that this is impossible, but that to cause the heat to flow from the condenser into the boiler we must have recourse to some artificial process, which, like working a heat-engine backward" (an ice-machine), "involves in some way or other, directly or indirectly, the expenditure of energy to as great or greater amount than we can recover by utilizing that heat in the boiler; and the second law of thermodynamics merely amounts to a statement of this impossibility."

After describing with some detail the principal forms of ice-machines produced since Jacob Perkins's invention in 1834, and with the aid of the foregoing data, I shall be in a better position to explain a new type of ice-machine, the least complicated and most economical capable of construction, and to which I have applied a name perhaps more explicit than elegant in any classic sense, viz, Thermo-glacial Engine.

Meanwhile it is necessary, for the complete understanding of the subject of artificial refrigeration, that some notice be taken of frigorific mixtures and the laws which control the thermometric phenomena due to the admixture of water or ice and certain salts.

G.—ON CRYOGENS OR COLD-GENERATING SALTS.

Prof. Frederick Guthrie, of the Science and Art Department, South Kensington, London, has contributed some very valuable memoirs to the Physical Society on salt-solutions and attached water. Space precludes

my giving more than a bare statement of the important results he has arrived at by accurate experiment and admirable reasoning. Under the name "cryohydrates" he includes the bodies resulting from the union of water with another body, and which solidify below the freezing-point of water. These compounds have a constant composition and definite freezing and melting points, and can only exist in the solid form below 0° C. As Mr. Guthrie says, perhaps one of the most interesting aspects of the experimental results is the establishment of fixed temperatures below zero. With the exception of the melting-points of a few organic bodies, such as benzol, and the boiling-points of a few liquids, such as liquid ammonia, sulphurous acid, and carbonic acid, and the defined temperatures to be got from freezing-mixtures, there are no means in the hands of the physicist for obtaining and maintaining with certainty and ease a fixed temperature below 0° C. Now, if we surround a body with one of the solid cryohydrates, the body is kept at a corresponding temperature as long as any of the cryohydrate remains solid, and this with as much certainty as the temperature, 0° C. can be maintained by melting ice. We thus command temperatures between —23° and 0° C. with the greatest precision. Mr. Guthrie has applied the term "cryogen" to an appliance for obtaining a temperature below 0° C.

Looking upon ice as the cryohydrate of water, this is seen to shrink as it loses heat till it reaches 4° C. At this point ice is formed, which, however, is dissolved in the water. A solution is obtained having a temperature of solidification below 4° C., namely, at 0° C. or 32° Fahr. At this the ice and the water solidify together, producing the compound body or cryohydrate called ice, which is thus a cryohydrate of water. The expansion from 4° to 0° (from 39°.2 to 32° Fahr.) is due to the greater and greater amount of ice which the water holds in solution, and whose expansion is greater than the contraction of the water due to the diminished temperature.

Common salt and ice solidify immediately below the temperature —21° to —22° C., which is the lowest temperature to be got by an ice salt-freezing mixture. This minimum temperature seems to be attained between the somewhat wide margins of 3 of salt to 1 of ice, and 1 of salt to 2 of ice. This shows that "freezing-mixtures may be bodies of precise temperatures under widely-varying circumstances."

"It is clear," says Dr. Guthrie, that the liquid portion of a freezing-mixture is a brine of such a composition as to resist solidification at the temperature of the freezing-mixture.

"The enormous latent heat of water, the fact that the specific heat of ice is only about half that of water, while the specific heats of all salts are far less than that of ice, and, therefore, *a fortiori*, less than that of water, together with the good thermal conductivity of water, all argue that, if constantly stirred, all parts of a freezing-mixture will have the same temperature. The fact that the liquid portion of a freezing-mixture of ice and a solid salt is the cryohydrate of that salt, insures the

identity of the resulting temperature under various conditions of proportion. The constant tendency to the formation of this cryohydrate by contact between the solids is alway seeking to depress the temperature; while the solidification of the cryohydrate at an indefinitely small fraction of a degree below the temperature of the freezing-mixture and the consequent liberation of heat insure the temperature against such fall."

"Statements, therefore," says Professor Guthrie, "whether previously made by myself or others, that it is advantageous to weigh the salt and ice in definite proportions, that the ice should be dry, that snow is preferable to ice on account of its state of finer division, that additional cold is produced by previously cooling the ice or salt, or both, are to be put aside as untrue—untrue, that is, as far as the temperature or heat tension is concerned. To obtain the greatest quantity of heat absorption with a given amount of salt, such a quantity of ice must be taken as will form with the salt a cryohydrate."

Within very wide limits as to quantity, the temperature of a freezing-mixture may be very independent of the temperature both of the salt and of the ice. Professor Guthrie established this as follows: an ounce of finely-powdered chloride of sodium was cooled in a flask surrounded by a freezing-mixture till its temperature was -15° C. It was then stirred with four ounces of ice, which had been cooled and had the temperature -10°. As soon as liquefaction began, the temperature -22° was reached; and this degree of cold was never surpassed.

The same degree of cold (-22°) resulted from the mixture of 1 ounce of sodium chloride at -15° with 4 ounces of ice at 0°; also, when 1 ounce of salt at $+12^\circ$ C. was mixed with 4 ounces of ice at -12° C.

Indeed, the margin of temperature may be greatly extended. Thus, 1 ounce of sodium chloride in powder was heated to incipient redness and thrown upon 5 or 6 ounces of ice at 0°; after a few minutes' constant stirring, the temperature had reached -22°.

One ounce of dry anhydrous sodium sulphate was heated nearly to redness and thrown upon 4 ounces of ice at 0°. In a few minutes the temperature had sunk to $-0^\circ.7$. Again, an ounce of anhydrous copper sulphate was heated to about 600° C. and thrown upon 4 ounces of ice; the temperature at once sank to $-0^\circ.5$; whereas, if mixed at ordinary temperatures, the reduction would only have been to -2° C.

H.—SPECIAL EXAMPLES OF CRYOHYDRATES.

Some examples of special interest among cryohydrates may be noticed. Ice and chloride of ammonium solidify at -15° C., taking the form of a brilliant white, apparently flocculent mass, lighter than the unsolidified liquid. Decanting liquid separated after awhile, the solidifying parts were seen to be minute crystals, very much resembling ice-flowers, but opaque. "The sides of the beaker become studded with transparent

crystals of four sides, which are streaked parallel to the sides. By and by these crystals become perfectly white and opaque, and a third axis of crystallization is developed, which was at first suppressed. The crystals are perfectly beautiful, resembling, where opaque, frosted silver. On allowing a thick cup to freeze, and breaking it, an exquisite pearly appearance is presented. The structure appears then quite fibrous, the fibres running perpendicular to the axis of the cup; and the appearance, as far as structure is concerned, is similar to that of sublimed chloride of ammonium. The temperature remains constant at —15° C., even to perfect dryness."

Shortly after my return to England from Texas, in 1869, where I felt the want of a harmless antiseptic, I was the cause of the manufacture, commercially, of the chloride of aluminium. The strong solution obtained by the double decomposition of chloride of calcium and sulphate of alumina absorbs water from the air with great avidity. On immersing fish in a dilute solution of this chloride, a very remarkable phenomenon was observed. Alumina was deposited on the surface, and hydrochloric acid penetrated the tissues, preserving them under proper management with very slight adventitious flavor. I found that strong solutions would resist congelation to below —10° Fahr. Professor Guthrie found that when thrown upon several times its own weight of ice, the two would liquefy, and the temperature stand above 0° C. "The strongest commercial solution of chloride of aluminium, however, when at the temperature of the air, or at 0°, or at 100° C., will reduce the temperature to —13° C. when poured upon three or four times its own weight of ice." "I suppose," continues Mr. Guthrie, "the anhydrous chloride may be viewed as separating the atoms of the water-molecule, as is supposed to be the case with the chlorides of phosphorus."

In using hydrochloric acid as a cryogen with ice, Professor Guthrie obtained a normal acid, and poured it, in various proportions, upon ice at 0°. Fifty grammes of ice were used in each experiment. The table shows within what small limits of ratio the minimum temperature is reached. The weight of ice is taken as unity.

Weight of ice at 0° C.	Weight of hydrochloric acid.	Resulting temperature.
1	1.5	— 3°
1	0.4	—26°
1	0.3	—23°
1	0.2	—19°

"We are, therefore," says Mr. Guthrie, "when dealing with a cryogen, one of whose constituents is a liquid, much more limited in the range of ratio which we may employ, to procure the maximum cold, than is the case when both are solid."

I.—TABLE OF FREEZING-MIXTURES (GUTHRIE).

The temperatures obtained on mixing the salt with three to six times its weight of ice in lumps of the size of *a pea* downwards.

Name.	Formula of salt.	Temperature.	
		Cent.	Fahr.
Sodium bromide	$Na\,Br$	− 28.0	− 18.4
Ammonium iodide	$N\,H_4\,I$	− 27.0 − 28.0	− 16.6 − 18.4
Sodium iodide	$Na\,I$	− 26.5	− 15.7
Copper chloride	$Cu\,Cl_2$	− 24.5	− 12.5
Potassium iodide	$K\,I$	− 22.0	− 7.6
Sodium chloride	$Na\,Cl$	− 22.0	− 7.6
Magnesium chloride	$Mg\,Cl_2 + 6\,H_2O$	− 20.5	− 4.9
Strontium chloride	$Sr\,Cl_2 + 6\,H_2O$	− 18.0	− 0.4
Ammonium sulphate	$2\,N\,H_4,\,S\,O_4$	− 17.5	+ 1.0
Ammonium bromide	$N\,H_4\,Br$	− 17.0	1.4
Ammonium nitrate	$N\,H_4\,N\,O_3$	− 17.0	1.4
Sodium nitrate	$Na\,N\,O_3$	− 16.0	3.2
Ammonium chloride	$N\,H_4\,Cl$	− 16.0	3.2
Iron chloride	$Fe\,Cl_3$ (commercial)	− 16.0	3.2
Calcium nitrate	$Ca\,2\,N\,O_3 + 4\,H_2O$	− 14.0	6.8
Potassium bromide	$K\,Br$	− 13.0	8.6
Aluminium chloride	$Al\,Cl_3$ (in strong solution)	− 13.0	8.6
Potassium chloride	$K\,Cl$	− 10.5	13.1
Potassium chromate	$K_2\,Cr\,O_4$	− 10.2	13.7
Barium chloride	$Ba\,Cl_2 + 2\,H_2O$	− 7.2	20.3
Strontium nitrate	$Sr\,2\,N\,O_3$	− 6.0	21.2
Magnesium sulphate	$Mg\,S\,O_4 + 7\,H_2O$	− 5.3	23.5
Zinc sulphate	$Zn\,S\,O_4 + 7\,H_2O$	− 5.0	23.0
Potassium nitrate	$K\,N\,O_3$	− 3.0	26.6
Sodium carbonate	$Na_2\,C\,O_3$	− 2.2	28.3
Copper sulphate	$Cu\,S\,O_4 + 5\,H_2O$	− 2.0	28.4
Iron sulphate	$Fe\,S\,O_4 + 7\,H_2O$	− 1.7	30.
Potassium sulphate	$K_2\,S\,O_4$	− 1.5	....
Potassium bichromate	$K_2\,Cr_2\,O_7$	− 1.0	30.2
Barium nitrate	$Ba\,2\,N\,O_3$	− 0.9	....
Sodium sulphate	$Na_2\,S\,O_4 + 10\,H_2O$	− 0.7	....
Potassium chlorate	$K\,Cl\,O_3$	− 0.7	....
Ammonia alum	$Al_2\,N\,H_4\,2\,S\,O_4 + 12\,H_2O$	− 0.4	....
Mercury perchloride	$Hg\,Cl_2$	− 0.2	....
Ammonium oxalate	$N\,H_4\,C\,O_2$	− 0.2	....

The temperatures here recorded are the lowest attainable for each salt independently of the temperature of the salt and its degree of crystallhydration.

Professor Guthrie has determined that *a cryohydrate undergoing solidification may be considered physically as the homologue of a saturated salt-solution in the act of boiling.* Comparing the decomposition of a salt-solution by the loss of heat with the decomposition by gain of heat when such a solution boils, the following points may be noted:

(1.) A solution poorer than the cryohydrate loses heat; ice is formed.	(1.) A solution poorer than that saturated at a given temperature receives heat; vapor is formed.
(2.) This goes on until the proportion of the cryohydrate is reached, the temperature falling.	(2.) This goes on until saturation is reached, the temperature rising.
(3.) The cryohydrate may be reached by freezing out ice from a weaker solution, or by any other withdrawal of water.	(3.) Saturation may be reached by evaporation, boiling, or any other withdrawal of water.
(4.) When ice separates from a liquid, it remains in contact with the liquid, and endeavors to redissolve therein.	(4.) Vapor separated from a liquid is removed from the field of contention, unless the liquid be enclosed with the vapor.

(5.) When by the separation of ice the proportion of the cryohydrate is reached (nearly independent of pressure) ice and the salt separate simultaneously.

(6.) The two bodies (ice and salt) being crystallizable solids, unite to form a crystallizable cryohydrate which exhibits a constant gravimetric composition.

(7.) A cryohydrate in the act of solidification shows identity of composition between the solid and liquid portions. The temperature of solidification is constant.

(5.) When by the separation of vapor the proportion of saturation is reached, (very dependent on pressure), vapor and the salt separate simultaneously.

(6.) One being a solid and the other a vapor, they do not unite, but in their separation preserve a constant gravimetric ratio under like conditions of pressure.

(7.) A saturated solution, when boiling, shows the same ratio between the vapor formed and the salt precipitated as exists between the liquid water present and the salt it holds in solution. The temperature of boiling is (under like pressure) constant.

J.—ORGANIC CRYSTALLOIDS IN WATER.

In discussing the behavior of a few organic crystalloids in aqueous solutions on being cooled and being heated, Professor Guthrie says: "With regard to glycerine, a very remarkable circumstance may be noticed. That it is crystalloid, we have had until lately (1) the indirect evidence depending upon its being an alcohol, and upon several alcohols being known in the solid and crystalline state, while others which are not so known get united with crystalline salts; (2) the direct evidence obtained from its diffusion through colloid septa. Lately, it has been observed to assume the form of a crystalline solid. Again, it has lately been employed in aqueous solution in Pictet's ice-machine as a non-freezable liquid, to yield heat to vaporizing sulphurous acid, and take it from water for the purpose of freezing the latter. The latter faculty of its solution to resist solidification below 0° C. proves, first, that it will form a cryogen, and, secondly, that it will form a cryohydrate; the latter fact again proving, as we shall see, that it is a crystalloid. Pure glycerine dried by being kept for a week over oil of vitriol *in vacuo*, when mixed with finely-crushed ice forms a cryogen whose temperature is —19° C." Professor Guthrie was not aware, when writing the above, that I originated the idea of using the aqueous solution of glycerine in ice-machines, and Mr. Pictet only employed it at the exhibition of scientific apparatus in South Kensington with my permission. The practical advantages have been demonstrated by the total cessation of accidents from ice forming in the refrigerator-tubes and bursting them, and from the absence of all galvanic or corroding action on the metals.

Glycerine, per cent. by weight.	Water, per cent. by weight.	Temperature at which solidification begins.	Nature of solid formed.
		°	
5	95	— 0.8 Cent.	Ice.
10	90	— 2.0 Cent.	Ice.
15	85	— 3.3 Cent.	Ice.
20	80	— 5.0 Cent.	Ice
25	75	— 6.2 Cent.	Ice.
30	70	— 8.8 Cent.	Ice.
35	65	—11.5 Cent	Ice.
40	50	—13.9 Cent.	Ice.
45	55	—16.7 Cent.	Ice.

Professor Guthrie has not succeeded in getting the cryohydrates of glycerine. As a cryogen, the glycerine behaves as hydrochloric acid and other liquid elements of cryogens, namely, the temperature obtained is lower if the liquid be previously cooled.

K.—CRYOGEN-MACHINES.

Under this name may be included any apparatus calculated to facilitate and bring about the regular admixture of water and a cryogen, the low temperature produced being utilized to make ice, freeze creams, &c. The only practical domestic machines are really of this kind, and to what extent they may hereafter render good service in households and some industries, especially in hot climates, depends much on the careful application of the knowledge acquired by Professor Guthrie and his followers. Many of the salts available for this purpose are remarkable for their stability, and may be used for an indefinite period of time. The cost of the evaporation of water will determine the cost of the resulting cold, and the sun's heat may enable, the parched residents of tropical countries, to enjoy the comfort and luxury of very economical methods of artificial refrigeration.

In relation to fish-culture, the transportation of ova on steamers, and for securing definite and unvarying temperatures at small cost, in moderate compass, the *cryogen-machine* offers many advantages. At sea, exhaust steam may be had in any quantity to dry the salt. The time required to dry the salt, the amount of material to be cooled, and the mechanical facilities for the alternate liquefaction and solidification of the salt are matters of great practical moment which have received but little attention hitherto. In this direction we must anticipate a great revolution in artificial refrigeration, especially as applied to the subjects most immediately under consideration in this paper. I need, therefore, make no excuse for reproducing the following table, showing (1) the chemical formula of the salt, (2) the lowest temperature to be got by mixing the salt with ice, (3) temperature of solidification of the cryohydrate, (4) molecular ratio between anhydrous salt and water of its cryohydrate (water-worth or aquavalent), (5) percentage of anhydrous salt in portions of cryohydrate last to solidify, (6) percentage of anhydrous salt in crop of cryohydrate before the last.

Table of cryogens and cryohydrates. (Guthrie.)

Name of salt.	Formula.	Temperature of cryogen, Cent.	Temperature of solidification of cryohydrate, Cent.	Molecular ratio, or water-worth or aquavalent.	Percentage of anhydrous salt in last cryohydrate, M. L.	Percentage of anhydrous salts in next to last cryohydrate.
		°	°			
Sodium bromide	$NaBr$	−28	−24	8.1	41.33	41.61
Ammonium iodide	NH_4I	−27	−27.5	6.4	55.49	57.6
Sodium iodide	NaI	−26.5	−15	5.8	59.45	59.39
Potassium iodide	KI	−22	−22	8.5	52.07	51.72
Sodium chloride	$NaCl$	−22	−22	10.5	23.60	......
Strontium chloride	$SrCl_2 + 6H_2O$	−18	−17	22.9	27.57	27.5
Ammonium sulphate	NH_4SO_4	−17.5	−17	10.2	41.70	42.2
Ammonium bromide	NH_4B_2	−17	−17	11.1	32.12	32.17
Ammonium nitrate	NH_4NO_3	−17	−17.2	5.72	43.71	43.26
Sodium nitrate	$NaNO_3$	−16.5	−17.5	8.13	40.80	41.3
Ammonium chloride	NH_4Cl	−16	−15	12.4	19.27	19.27
Potassium bromide	KBr	−13	−13	13.94	32.15	31.80
Potassium chloride	KCl	−10.5	−11.4	16.61	20.03	20.07
Potassium chromate	K_2CrO_4	−10.2	−12	18.8	36.27	36.41
Barium chloride	$BaCl_2 + 2H_2O$	− 7.2	− 8	37.8	23.2	24.0
Strontium nitrate	Sr_2NO_3	− 6	− 6	33.5	25.99	25.91
Magnesium sulphate	$MgSO_4 + 7H_2O$	− 5.3	− 5	23.8	21.86	......
Zinc sulphate	$ZnSO_4 + 7H_2O$	− 5	− 7	20.0	30.84	......
Potassium nitrate	KNO_3	− 3	− 2.6	44.6	11 20	......
Sodium carbonate	Na_2CO_3	− 2.2	− 2	92.75	5.97	......
Copper sulphate	$CuSO_4 + 5H_2O$	− 2	− 2	43.7	16.89	......
Iron sulphate	$FeSO_4 + 7H_2O$	− 1.7	− 2.2	41.41	16.92	17.35
Potassium sulphate	K_2SO_4	− 1.5	− 1.2	114.2	7.80	7.5
Potassium bichromate	$K_2Cr_2O_7$	− 1	− 1	292.0	5.30	......
Barium nitrate	$Ba2NO_3$	− 0.9	− 0.8	259.0	5.30	2.88
Sodium sulphate	$Na_2SO_4 + 10H_2O$	− 0.7	− 0.7	165.6	4.55	......
Potassium chlorate	$KClO_3$	− 0.7	− 0.5	222.0	2.93	4.2
Ammonia alum	$Al_2N_4H2SO_4 + 12H_2O$	− 0.4	− 0.2	261.4	4.7	......
Mercury perchloride	$HgCl_2$	− 0.2	− 0.2	450.0	3.24	3.29

Professor Guthrie has, from the evidence thus adduced, enunciated the general law that if we define as similar salts either (1) those which consist of the same acid united with bases belonging to the same chemical group, or (2) those which consist of the same base united with acids belonging to the same group, or those whose bases belong to the same group, and whose acids belong to the same group—then, *of similar salts, the one which produces the greatest cold when used in a freezing-mixture unites as a cryohydrate with the fewest molecules of water.* And to the following law there seems to be only one pronounced exception: *The temperature at which the cryohydrate is formed is the same as the temperature of the corresponding freezing-mixture.* This latter law, however, has to be taken with reserve as far as those salts are concerned which, like chloride of aluminium and chloride of magnesium, decompose water, and also in regard to those bodies which, like chloride of calcium, unite with water under the liberation of much heat.

L.—CHLORIDE OF CALCIUM ICE-MACHINE.

The first practical cryogen-machine was patented in 1855 by Mr. C. W. Siemens under the title "Improvements in cooling and in freezing water and other bodies." In the apparatus required for these purposes

a cistern "rests upon a second cistern." The upper one (of wood or other material) is lined with metal in such manner that a non-conducting substance may be inserted into the spaces "which are left at certain parts between the sides of the cistern and the lining, and between its floor and lining." A plate "extending along two sides of the cistern" divides off a chamber (called the salt-chamber), and another plate on the opposite sides divides off a smaller chamber (called the water-chamber) which communicates with a central chamber by a pipe on the under side of both. The central chamber contains "a series of guides or tubes arranged alternately close on to and a little above" the bottom lining, so as to cause "an upward and downward current of the cooling solution." "An insulating partition on all the four sides" (composed of plates with charcoal powder between them) divides off a chamber "from the space or chamber immediately around the central chamber." And this space is occupied by the vessels which contain the water to be frozen. The lower cistern contains a coil of pipes, and the overflow from the upper cistern is indicated by an outlet-pipe into the lower one, and surrounds the coil. A pump raises the solution, as may be required, from the lower cistern to a third cistern, which is mounted over a boiler, and communicates with it by a pipe carrying a ball tap. A pipe passing from the boiler is extended into a worm inside the third cistern; it then descends and is united with one end of the coil in the lower cistern; the other end of the coil extends upwards "and bends over and into the water-chamber." There is a discharge-tap from the boiler, and under the tap is "a crystallizing vat." The central chamber is filled with crystallized chloride of calcium. The vessels are filled with the substance to be frozen, and are closed with insulating covers. The water-chamber is filled with water, which passes into the central chamber, and penetrates "a considerable mass of the crystals in passing upwards and downwards between the tubes or guides into the space or chamber around." The solution fills this space "up to the level of the overflow of the insulating partition," and passing between the vessels "descends into the narrow surrounding chamber"; when this is filled, the surplus is discharged by the outlet-pipe into the lower cistern. Here the solution absorbs a further portion of heat from the coil "containing condensed water from the boiler." The pump raises the solution into the third cistern; the solution descends, and, having "reached its proper level in the boiler," is made to boil. The steam passing through the pipe and worm is condensed by contact with the solution in the third cistern; it then descends into the coil in the lower cistern, "is considerably cooled by contact with the solution" in this cistern, and rises thence into the water-chamber, "to be there almost reduced to the freezing-point previous to its again entering" the central chamber. "The concentrated solution is drawn from the boiler from time to time," is received into the crystallizing vat, and is there crystallized in from 12 to 24 hours. The crystals thus obtained are put into the salt-chamber "to be cooled down to nearly

32° Fahr., and to be again dissolved" in the central chamber. To produce "intense degrees of cold in the apparatus," a small quantity of ice or snow is put into the central chamber.

In 1858, Mr. Siemens improved the construction of the refrigerator in this machine, and in the system of evaporating the spent solution for the purpose of recrystallization or reproduction of the salt or compound which has been dissolved. He used evaporating-pans over a furnace, or the flues thereof, in such a manner as to afford the means of drawing off the contents of one or more pans into one or more other pans.

Another device for revolving ice-moulds with a freezing-mixture around them was patented in England, in 1862, by Giovanni Battista Toselli, and this form of apparatus is being sold in Paris. The invention consists, first, in the vertical rotation of the liquids to be congealed; secondly, in the very simple shape of the machine with concentric sides and opposite openings, whether such machine be made in whole or in part of metal; thirdly, in the said machines being suitable for the production of ice by chemical means.

M.—GASES AND THEIR LIQUEFACTION.

Van Helmont introduced the word "gas," and in 1752 he established the existence of gas sylvestre (carbonic acid), which Black, three years later, termed *fixed air*. To Van Helmont is due the distinction between a gas and a vapor. Aeriform fluids would not liquefy in cooling, whereas, vapors, he said, required heat to maintain them in the free molecular or gaseous state.

Daniel Bernouilli first stated that gases are formed of material particles, free in space, and animated by very rapid rectilinear movements. The tension of elastic fluids results from the shock of these particles against the sides of the containing vessels. The gaseous molecules manifest the energy of motion termed kinetic (from κῖνέω, I move). Lucretius held that the different properties of matter depended on such a motion. The law of Boyle or of Mariotte follows as a natural consequence of this idea, and it is this law which interests specially all those who are engaged in the liquefaction of gases and the abstraction of heat by these from surrounding objects, as they return to the gaseous state.

As Professor Wurtz puts it in a recent lecture:* "Suppose a gas occupying a certain volume, and composed of a definite number of material particles, or molecules, so called, to be contained in a closed vessel, such as the cylinder of an air-pump, the pressure on the piston will be determined by the number of shocks of the molecules diffused through the neighboring stratum of gas. If, then, the volume of gas be reduced, the number of particles in this layer will be increased as well as the sum of the shocks, and the pressure will be increased in proportion thereto. *Temperature* is determined by these movements of gaseous molecules.

* On the constitution of matter in the gaseous state, being the Faraday lecture delivered November 12, 1878, at the Royal Institution, London.

The energy of the rectilinear movements, that is to say, the mass of the gaseous molecules multiplied by the square of the velocity, gives the measure of the temperature." The law of Boyle (1662) is as follows: The volume of a gas varies inversely as the pressure; or, in other words, the pressure of a gas is proportional to its density. Cohesion, or the tendency to molecular aggregation, which is so strong in the more liquefiable gases, causes deviations from the law of Boyle, especially near the liquefying point. This cohesion is interfered with materially by the admixture with a condensable gas of one of the, hitherto called, permanent gases. For instance, if air becomes mixed with ammonia or even with ether vapor, the pressure at which the gas liquefies is greatly increased. The presence of air, or of some one of the more incondensable gases in a freezing-machine, interferes materially with the changes in physical state, so essential to the operation of the machine.

Heat absorbed also most naturally affects cohesion; as the temperature of a gas rises beyond a certain well-defined limit for each gas, the molecular movements triumph over cohesion and liquefaction is rendered impossible; as Dr. Andrews states, the *critical point* is attained. This point has been called by Medeleyeff the *absolute boiling-point.* Just as the addition of heat activates the motion to such an extent that the molecules cannot be brought to rest by any amount of superincumbent pressure that we can apply, so the opposite condition may be imagined when all heat has been abstracted. When heat motion ceases, this is the absolute zero, —460°.66 Fahr., or —273°.7C.

Dalton extended Boyle's law, and declared that if different gases, which do not act chemically on each other, are mixed together, the pressure exerted is likewise the sum of the separate pressures of the diferent gases, but Dr. Andrews has shown* that by mixing nitrogen with carbonic acid the critical temperature is lowered, and that Dalton's law of density of mixed vapors only holds at low pressures and at temperatures greatly above their critical points.

It is fifty-five years since Faraday (1823) gave precision to our knowledge concerning the effects of pressure and cold on bodies usually gaseous at ordinary temperatures and atmospheric pressure. Northmore had compressed chlorine into a liquid† in 1805–1806. Faraday condensed chlorine into a liquid in 1823, and afterwards succeeded in liquefying hydrochloric acid, ammonia, and other gases. He afterwards learned that Monge and Clouet had liquefied sulphurous acid gas in 1800, and in 1824 Bussy accomplished this at ordinary atmospheric pressure at 12° to 15° below 0 Cent.

Natterer, of Vienna, compressed oxygen, hydrogen, and nitrogen to 3,000 atmospheres without effecting liquefaction.

Dr. Andrews‡ has demonstrated that the gaseous and liquid states

---

* Proceedings of the Royal Society, 1875.

† Northmore, Nicholson's Journal, XII 368; XIII, 232.

‡ The Bakerian Lecture, Phil. Transactions, 1869.

are only distant stages of the same condition of matter and are capable of passing into one another by a process of continuous change. Confusion has arisen in the use of the almost interchangeable words *gas* and *vapor*. Ether in the state of gas is called a vapor, whereas ammonia and sulphurous oxide in the same state are called gases; yet they are all vapors—the ether from a liquid boiling at 35°, the sulphurous oxide from a liquid boiling at —10°, and the ammonia from one boiling at —37°. The distinction, says Dr. Andrews, is thus determined by the trivial condition of the boiling-point of the liquid, under the ordinary pressure of the atmosphere, being higher or lower than the ordinary temperature of the atmosphere. Such a distinction may have some advantages for practical reference, but it has no scientific value. The critical point of temperature affords a criterion for distinguishing a vapor from a gas, if it be considered important to maintain the distinction at all. Many of the properties of vapors depend on the gas and liquid being present in contact with one another; and this we have seen can only occur at temperatures below the critical point. We may accordingly define a vapor to be a gas at any temperature under its critical point. According to this definition a vapor may, by pressure alone, be changed into a liquid, and may, therefore, exist in presence of its own liquid; while a gas cannot be liquefied by pressure—that is, so changed by pressure as to become a visible liquid distinguished by a surface of demarcation from the gas. If the distinction be accepted, continues Dr. Andrews, carbonic acid will be a vapor below 31° C., a gas above that temperature; ether a vapor below 200°, a gas above that temperature.

The fact that Jacob Perkins, who had designed the first practical freezing-machine, had liquefied gases and probably atmospheric air has not met with the attention it deserves, and believing, as I do, in the true genius of this admirable observer, I perhaps attribute more importance than others might to the following note from Faraday's Experimental Researches in Chemistry and Physics. He says: "As my object is to draw attention to the results obtained in the liquefaction of gases before the date of those described in the Philosophical Transactions for 1823, I need not, perhaps, refer to the notice given in the Annals of Philosophy, N. S., VI, 66, of the supposed liquefaction of atmospheric air by Mr. Perkins, under a pressure of about 1,100 atmospheres; but as such a result would be highly interesting, and is the only additional one on the subject I am acquainted with, I am desirous of doing so, as well also as to point out the remarkable difference between that result and those which are the subject of this and the other papers referred to. Mr. Perkins informed me that the air upon compression disappeared, and in its place was a small quantity of a fluid, which remained so when the pressure was removed, had little or no taste, and did not act on the skin. As far as I could, by inquiry, make out its nature, it resembled water; but if upon repetition it be found really to be the product of compressed common air, then its fixed nature shows it to be a result of a very differ-

ent kind to those mentioned above, and necessarily attended by far more important consequences."

It is, to say the least, singular that Faraday was not aware in 1823 that any of the gases had been liquefied. This is his own statement, and no one who knows Faraday's character can doubt that he believed what he wrote; but a letter by Faraday claiming the authorship of a paper previously published, over the initial letter of his Christian name, appeared in the very same volume of the Annals of Philosophy referred to above, published in 1823, and which contains the following editorial paragraph: "A paper on the compressibility of water, air, and other fluids, and on the crystallization of liquids, and the liquefaction of aeriform fluids, by simple pressure, was prepared by Mr. Perkins for the purpose of submitting it to the Royal Society; but it was accidentally misplaced previously to the last meeting, and, therefore, could not be announced to the society with the other papers. It contained, we are informed, a minute description, accompanied with figures, of his compressing apparatus; a diagram, showing the ratio of compressibility of water, beginning at the pressure of 10 atmospheres, and proceeding regularly to that of 2,000; and some experiments on the compression of atmospheric air, which appears by them to follow a law varying from that generally assigned to it by philosophers. Mr. Perkins intended to announce also, in this paper, that he had effected the liquefaction of atmospheric air and other gaseous substances, by a pressure equal to that of about 1,100 atmospheres; and that he had succeeded in crystallizing several liquids by simple pressure." In a paper "On the progressive compression of water by high degrees of force with some trials of its effects on other fluids," by J. Perkins, read June 15, 1826, in the Philosophical Transactions for 1826, I find the following:

"With the same apparatus I also made experiments on the compression of other fluids. The most remarkable result I obtained was with concentrated acetic acid; which, after compression with a force of 1,100 atmospheres, was found to be beautifully crystalized, with the exception of about $\frac{1}{10}$ part of fluid, which, when poured out, was only slightly acid.

"I next applied the apparatus to the compression of æriform fluids.

"In the course of my experiments on the compression of atmospheric air, by the same apparatus which had been used for compressing water, I observed a curious fact, which induced me to extend the experiment, viz: that of the air beginning to disappear at a pressure of 500 atmospheres, evidently by partial liquefaction, which is indicated by the quicksilver not settling down to a level with its surface. At an increased pressure of 600 atmospheres, the quicksilver was suspended about $\frac{1}{8}$ of the volume up the tube or gasometer; at 800 atmospheres, it remained about $\frac{1}{3}$ up the tube; at 1,000 atmospheres, $\frac{2}{3}$ up the tube, and small globules of liquid began to form about the top of it; at 1,200 atmospheres the quicksilver remained $\frac{3}{4}$ up the tube, and a beautiful transparent

liquid was seen on the surface of the quicksilver, in quantity about $\frac{1}{2000}$ part of the volume of air. The gasometer was at another time charged with carburetted hydrogen," and "it was subjected to different pressures, and it began to liquefy at about 40 atmospheres, and at 1,200 atmospheres the whole was liquefied."

"These instances of apparent condensation of gaseous fluids were first observed in January, 1822; but for want of chemical knowledge requisite to ascertain the exact nature of the liquids produced, I did not pursue the inquiry further; and as the subject has been taken up by those who are eminently qualified for the investigation, I need not regret my inability to make full advantage of the power I had the means of applying."

Jacob Perkins knew probably more than any of his contemporaries as to the means whereby an apparatus could be constructed to stand such pressures. He afterwards invented the steam-gun, and no doubt his knowledge of the liquefaction of gases led him directly to the recondensation of the ether vapor in the ice-machine patented, a drawing of which is appended to this paper. Sir Humphrey Davy appeared in no admirable light on this question in relation to Faraday. He was president of the Royal Society in 1823, and in this year he asked his pupil and assistant to liquefy chlorine. Can Perkins's important paper, drawings and all, have been lost by mere accident? Dr. Andrews has pointed out that to determine the certainty of the liquid and solid state of matter is a much more difficult subject for experiment than the relation between gases and liquids. In this relation Mr. Perkins's observations of the crystalization of acetic acid under pressure is at all events interesting.

However this may be, we may repeat in Mr. Wurtz's words that "the experiments of MM. Raoul Pictet and Cailletet have removed from science the distinction between permanent and condensable gases." Cailletet liquefied oxygen and carbonic oxide on the 2d of December, 1877. Being a candidate for election to a seat in the Academy of Sciences he delayed the announcement, after having consigned a statement of the discovery to a sealed packet, till the session of the 24th of December. At the same time Raoul Pictet's results by low temperature produced with the combined aid of sulphurous and carbonic acid gases were published, and confirmed Cailletet's experiments in which liquefaction has been induced by "détente" or expansion of the gas compressed at low temperature. On the last day of 1877 Cailletet liquefied hydrogen, nitrogen, and atmospheric air, and on the 11th of January M. Pictet solidified hydrogen, proving it to be a metal, as previously supposed by Professor Dumas.

This suspicion had been almost transformed into certainty by the admirable work of Graham, in forming hydrogenium alloys—notably with palladium: and while palladium itself was known to be capable of but feeble magnetism, its hydrogenium alloy was found to become strongly magnetic.

Space forbids that I should prolong this history, but it is important

that I should enter into details concerning the one substance of all others capable of absorbing most heat in its transference from the liquid to the gaseous state. All other agents have, in America, practically given way in practice to ammonia, whether as liquid or aqueous ammonia in the Carré machines, or anhydrous ammonia compressed by mechanical means, used mostly by infringers of the Ch. Tellier patent.

N.—ON AMMONIA.

This agent, known to the early alchemists as *spiritus salis urinæ*, in the form of carbonate, was procured by Basil Valentine from sal ammoniac by the action of an alkali. Geber first imported sal-armoniacum from Asia to Europe in the seventh century, and, like sulphate of ammonia, it was obtained as a deposit in the immediate proximity of volcanoes as well as with the boric acid of the Tuscan Maremme. The origin of ammonia from the effete organic matter constantly poured off by the excreta of animals, or in the rotting of vegetable matter, explains its universal diffusion. Whereas we now obtain ammoniacal liquor, supplying commerce with this article, from gas-works where the remains of extinct plants are being burned, centuries since Europe depended on Egypt for the material distilled from the soot of burning camels' dung. Later on, human urine was employed in Europe; and before the era of gas-works animal refuse of all kinds, such as hoofs, horns, bones, &c., furnished the spirits of hartshorn, an aqueous solution, named in Latin *spiritus volatilis salis ammoniaci*. After Stephen Hales's experiment in 1727 by heating lime with sal-ammoniac, liquid ammonia was obtained which we find Cullen calling the quick-lime spirit of sal ammoniac, and he placed it at the head of the list of agents calculated to depress the thermometer by their volatility. In 1774, Priestley discovered what he called *alkaline air*, and Berthollet, in 1785, determined the nature of the gases composing it by the aid of the electric spark, and found them to be hydrogen and nitrogen.

Dr. Angus Smith, in a recent article in the Chemical News (July 26, 1878), says: "Ammonia must ever be one of the most interesting of chemical substances."

"It is now many years," says Dr. Smith, "since Liebig first surprised me by saying that iron ores and aluminous earths were capable of taking up ammonia, and if they were breathed upon we were able even to smell that substance." . . . "If you pick up a stone in a city, and wash off the matter on the surface, you will find the water to contain ammonia. If you wash a chair or a table, or anything in a room, you will find ammonia in the washing; and if you wash your hands you will find the same; and your paper, your pen, your table-cloth, and clothes all show ammonia; and even the glass cover to an ornament has retained some on its surface. You will find it not to be a permanent part of the glass, because you require only to wash with pure water once

or twice, and you will obtain a washing which contains no ammonia; it is only superficial."

Liquid ammonia (liquor ammoniæ), or the aqueous solution of ammonia of commerce contains varying quantities of ammonia in water, according to temperature. A mean usually stated is that water dissolves 700 volumes of the gas. At 0° C., 0.875 gramme or 1,148 cubic centimeters of ammonia gas are absorbed by one gramme of water under normal pressure. The avidity of the combination is attended with the evolution of heat, and this fact is demonstrated by passing a current of air through a cold concentrated solution of ammonia, displacing the gas, which carries off the heat of the intruded air, and the liquid falls below —40°, so that by this method mercury may be frozen.

At ordinary temperatures, ammonia is a transparent gas, alkaline in reaction, colorless unless the air contains a little hydrochloric acid, when visible white fumes appear. Its tension at different temperatures varies greatly.

The volumes of ammonia gas at different temperatures are, according to Andréeff, as follows:

Temperature...............	10° C.	0° C.	+ 10° C.	+ 20° C.
Volume	0.09805	1.000	1.0215	1.0450

The coefficient of expansion between —11° and 0° C. is, according to the mean of three observations by Jolly, 0.00155; so that at temperatures sufficiently removed from its boiling-point ammonia expands more than a gas.

At —38.5, according to Regnault, or at —35°.7, according to Loir and Drion, ammonia is liquid at atmospheric pressure. By a mixture of chloride of calcium and ice Guyton de Morveau condensed ammonia into a liquid at —52° C., and Bunsen at —40° C. Guyton de Morveau's original experiment, in which he liquefied ammonia at —21° C., shows the influence of an admixture of water in changing the properties of ammonia, an influence which Ch. Tellier had discovered when he recommended and patented the liquefaction by pressure of anhydrous ammonia in ice-machines.

The specific gravity of the liquefied anhydrous ammonia is 0.76, and it is a colorless, very mobile liquid, refracting light more powerfully than water.

Faraday solidified it at —103° Fahr., when its vapor tension was still 5 pounds to the square inch.

The pressures and temperatures at which ammonia gas, dried by chloride of calcium or fused caustic potash, could alone be liquefied, led to the idea, until Tellier dispelled it, that for the purposes of artificial refrigeration it could only be used with water. Prof. F. A. P. Barnard, of New York, one of the commissioners at the Paris Universal Exposition of 1867, wrote in the report I have elsewhere quoted a very clear and definite statement of the views then entertained. M. Tellier's patent was in the secret archives of the French patent-office, and indeed the diffi-

culties in the way of pumping ammonia gas had led him to resort by preference to another agent, patented simultaneously, viz, methylic ether. Professor Barnard says: "Gaseous ammonia is reduced to the liquid form by pressure; but at 20° C. (68° Fahr.) it requires a pressure of not less than eight and a half atmospheres to produce liquefaction, and at 25° C. (77° Fahr.) not less than ten. Thus the pressure required rises very rapidly with the temperature. On the other hand, to liquefy ammonia by cold merely, under the ordinary atmospheric pressure, requires a reduction of temperature down to 38°.5 below zero of the Centigrade thermometer. Ammonia, therefore, evaporates very rapidly even at temperatures extremely low; and as the latent heat of its vapor is great, being estimated at 514° C., it may be used as a powerful means of producing cold, provided any practicable method can be devised for removing the vapor as it is formed. To do this mechanically would require a pump of large dimensions; and inasmuch as considerations of economy as well as of health and the comfort of the operators would require that the vapor should be reduced by compression to the liquid state, the pump should be capable of exerting a pressure of from seven to ten atmospheres. *If, therefore, it were only by mechanical means that ammonia could be condensed, this substance could not be profitably used as a means of producing cold.*"

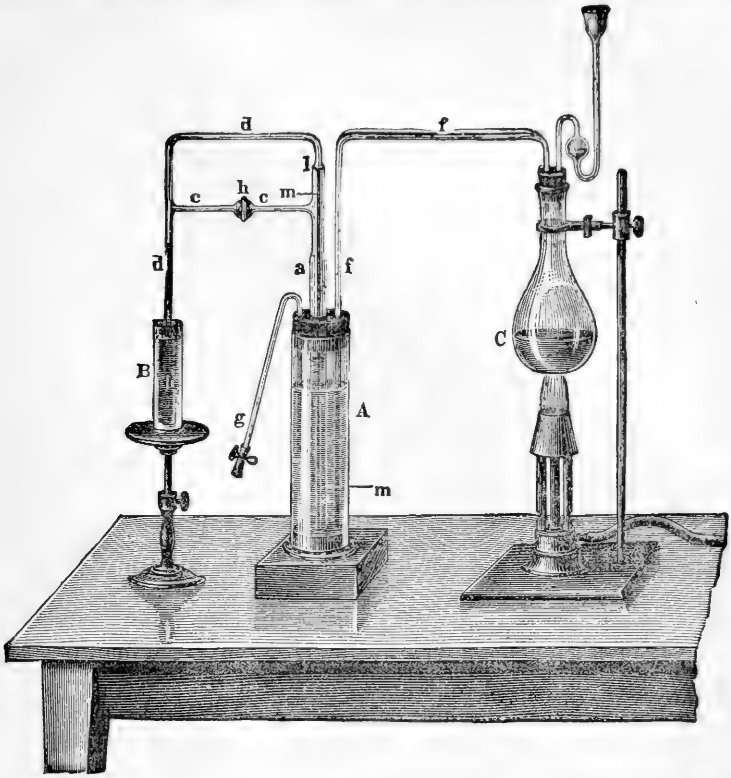
To show what at that time was meant by *liquid ammonia*, and the views Professor Barnard entertained of the unequalled value of ammonia vapor for the abstraction of heat, I have another passage to quote. He says: "It may thus be stated that the latent heat of a kilogram of liquid ammonia is equal to ninety *calories.** The latent heat of a kilogram of its vapor, that is to say, of ammoniacal gas, amounts to five hundred and fourteen *calories.* The latent heat of water, liberated in the act of congelation, is equal to seventy-nine *calories* per kilogram; so that one kilogram of ammonia would be capable by its evaporation of freezing six and one-half kilograms of water taken at the initial temperature of zero, or five kilograms taken at the temperature of 24° C. (75°.2 Fahr.)."

Alcohol absorbs ammonia readily. Messrs. Roscoe and Schorlemmer, in their admirable Treatise on Chemistry, furnish the following illustration and remarks:† "The condensation of ammonia by pressure and the production of cold by its evaporation can easily be shown by the following experiment: The apparatus required for this purpose consists essentially of two strong glass tubes (*a* and *b*), which are closed below and are connected together by the tubes (*c c*) and (*d d*). The tube (*d d*) ends at (*l*) in a narrower tube (*m m*), which is at this point melted into a tube (*a*). The tube (*a*) is three-fourths filled with an alcoholic solution of ammonia saturated at 8°, and then placed in the cylinder (A). The syphon-tube (*g*) and the tube (*f f*), which reach to the bottom of the

*A French *calorie* signifies the amount of heat required to raise the temperature of a kilogram of water, taken at 0° C. of temperature, 1° C., and this is adopted as a unit.

†I am indebted to Messrs. D. Appleton & Co. for the use of this cut.

cylinder, are fixed in position through the cork. In order now to perform the experiment, the cylinder (A) is nearly filled with warm water;



the glass stop-cock (*h*) is opened, and the tube (*b*) placed in ice-cold water. The water contained in the flask is now quickly boiled, and thus the water in (A) is rapidly heated to 100°, and the ammonia gas driven out of solution until by its own pressure it liquefies in (*b*). As soon as the condensation of liquid ammonia ceases, the ebullition is stopped, and a portion of the hot water is withdrawn from the cylinder by means of the syphon (*g*); cold water is allowed to enter the cylinder, and after awhile this is replaced by ice-cold water. The cylinder (B) is now removed, when the liquefied ammonia begins to evaporate, and is again absorbed by the alcohol, though only slowly. But on closing the stop-cock (*h*) the gas above the alcohol is quickly absorbed, and thus the equilibrium is disturbed. The ammonia now passes rapidly through the tube (*m m*), and is absorbed so quickly that the liquid ammonia in (*h*) begins to boil, by which the temperature is so much lowered that if a test-tube containing water is placed outside (*h*) it is soon filled with ice."

O.—THE PROGRESSIVE STAGES IN ICE-MAKING INVENTIONS.

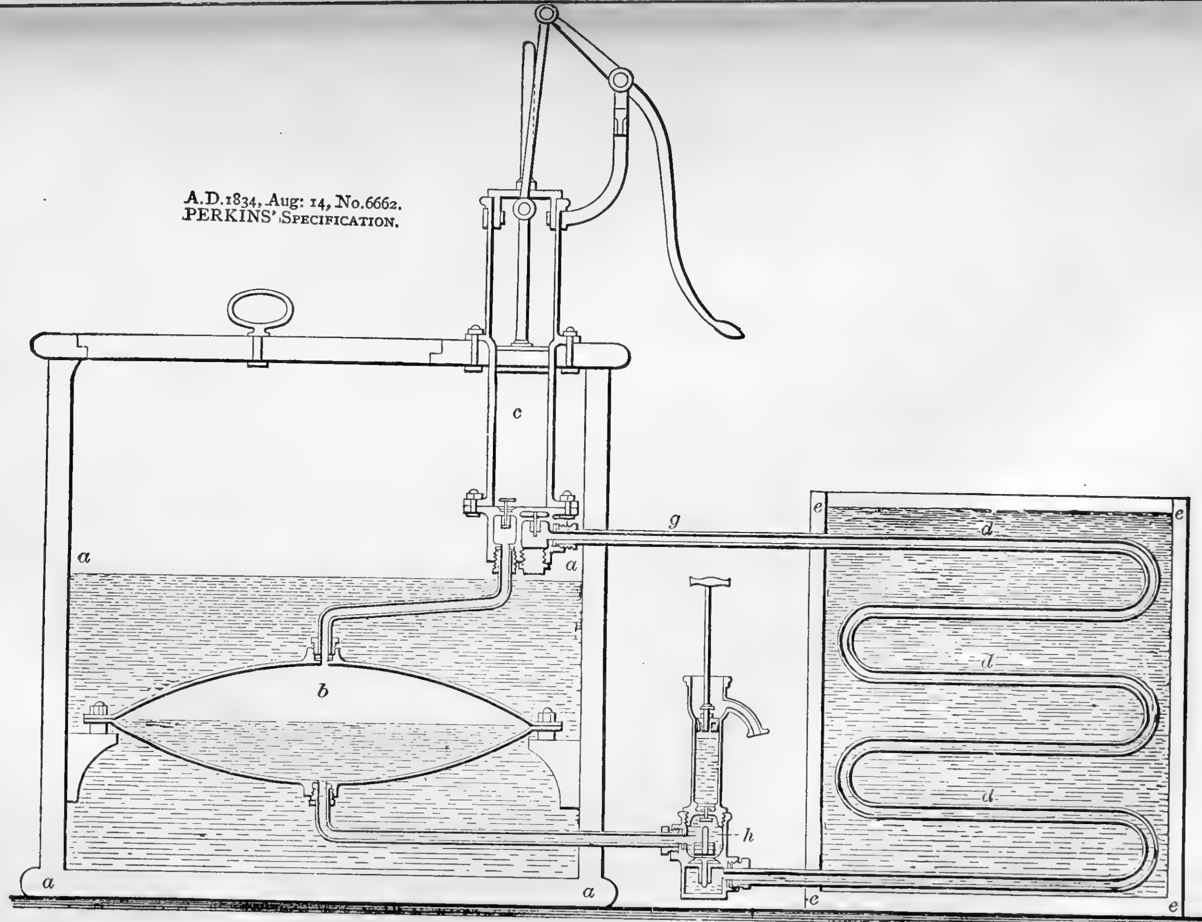
After Cullen's efforts to freeze water in the receiver of a vacuum-pump, by the rapid vaporization of ether, we have to skip to the second quar-

ter of the current century for a practical step in the direction of artificial-ice-machines. JacobPerkins, whilst a resident in London, devoted himself to the determination of the compressibility of gases and fluids, and as I have stated elsewhere, he undoubtedly recognized that gases and vapors might be condensed into liquids. This property he took advantage of in 1834, in his "Apparatus for Producing Ice and Cooling Fluids." "The object of my invention," said Perkins in his English patent, "is so to use a volatile fluid that the same (having been evaporated by the heat or caloric contained in the fluid about to be reduced in temperature) shall be condensed and come again into the vessel to be again evaporated and carry off further quantities of caloric."

"*Description of the drawing.*—*a* is a cistern for containing the water or other fluid from which it is desired to remove the caloric, and thus reduce its temperature, and even produce ice. This vessel should be well covered in and surrounded by a non-conducting material, in order to prevent the atmosphere or surrounding bodies giving off heat to the water or other fluid contained in such cistern; *b* is a vessel which is to contain the volatile fluid to be evaporated, and I chiefly recommend ether as the material to be evaporated, owing to the low degree of temperature at which, under ordinary circumstances, it becomes aeriform, but under the circumstances hereafter explained it will evaporate at still lower degrees of temperature; *c* is an ordinary pump, which I term the vapour-pump, it being intended to withdraw the vapour as it is generated in the vessel *b*, and to force it through the refrigerating-pipes *d*, contained in the cooling-tank *e*. There is to be a constant supply of cold water to the refrigerating-tank or vessel *e*, in order to cool down and condense the vapour in the pipes *d*. *f* is a pipe leading from the vessel *b* to the pump, having a valve to close the entrance into the pump, in order to prevent the vapour being forced back into the vessel *b* on the return stroke of the piston; *g* is a pipe having a valve opening outwards from the pump. This pipe *g* connects the pump with the refrigerator-pipes *d*; consequently the vapour, on coming into the pump, will be forced into the pipes *d*, and be there condensed, and thence return again into the vessel *b* to be again evaporated. But in order to secure a perfect condensation, I employ a valve, *h*, moderately weighted, say about atmospheric pressure, which prevents the return of the condensed ether till the same has become compressed and forced to give off its caloric to the condensing water on the outside of the condensing-tube *d*. The valve *h* is placed between the condenser and the vessel *b*, as shown in the drawing. It will be seen that most of the parts are shown in sections, in order that their construction may be evident.

"The apparatus being arranged as above described, and as shown in the drawing, I now prepare it for commencing work by filling every part of the apparatus with the volatile liquid to the utter exclusion of the atmospheric air, after which a sufficient quantity of the liquid is drawn off by the small pump attached to the valve *h*, to make sufficient space

A.D. 1834, Aug: 14, No. 6662.
PERKINS' SPECIFICATION.



for the vapour, say at least one-half. The progress of the evaporation of the liquid in the vessel *b* will depend on the quantity of vapour drawn off by the vapour-pump, as well as the quantity of caloric taken up from the liquid surrounding the vessel *b*, and thereby will its temperature be cooled down even to freezing."

I have been informed by Mr. Loftus Perkins, nephew of Mr. Jacob Perkins, that the great success of his uncle's first freezing-machine, as a matter of experiment, alarmed his partners lest he neglected the very lucrative business they were engaged in, and he was compelled to abandon a pursuit most congenial to his tastes. All that lacked to complete the ether-machine, was that extension of surfaces for the effectual freezing of a sufficiently large body of water whilst supplying heat to the ether for evaporation. Three inventors practically completed the work of Perkins, viz, Twining, Harrison, and Daniel Siebe. It were invidious to discriminate against either of these, but the ablest mechanic of the three, Mr. Siebe, having had all the fundamental principles laid before him, competent for any task he undertook, was limited to the engineering question, and to his skill in this respect we have to ascribe the practical success of ether-machines throughout the world.

Prof. Alexander C. Twining, of New Haven, has been justly regarded as having designed the first apparatus being an advance or improvement on the earlier invention of Mr. Jacob Perkins. His first patent was taken out in England on the 3d of July, 1850, and in the United States on November 8, 1853. The last was afterward extended to 1871. Professor Twining has permitted the publication of a statement of the steps taken in the progress of his invention. From 1848 to 1850 he was engaged in repeating Cullen's original ether experiments *in vacuo*, and found that one pound of ether, by its evaporation, was adequate to produce one pound and one-fifth of ice from water at 32° Fahr., besides cooling the ether 28°. He then determined that only 200 superficial feet of thin copper pipe would form an adequate surface for the production of 2,000 pounds of ice in twenty-four hours, even employing water of the temperature at the earth's equator. Ether was found to pass into vapor within a quarter as fast as water in locomotive-boilers; in a partial vacuum, 1 superficial foot of metal supplied heat even at the low temperature of 4° above zero to 5½ pounds of ether per hour.

In relation to the method of freezing water, it was ascertained that the rate of freezing was not appreciably obstructed by the thickness of ice already formed; a congelation of one-eighth of an inch in thickness could be realized per hour; 240 superficial feet would be a sufficient surface on which to freeze one ton of ice per day of twenty-four hours.

"The first attempt at a complete freezing construction was made in the summer of 1850. The machine had only capacity to freeze a pailful of water at one operation. It embraced the evaporating, the condensing, and the freezing parts" as afterward used. "But the mode of applying the freezing power was widely different. Six months were

consumed in trials with this machine, and the most discouraging practical difficulties were brought to light. It was not till long afterward that the inventor could discover the proper modes of obviating these difficulties. Nevertheless, this first small machine served as a complete verification of the facts, principles, and numerous small experiments which had been relied upon; and it thus became an encouragement in the end to attempt a vastly larger construction."

On the 15th of February, 1855, an engine calculated to produce 2,000 pounds of ice per day in ten freezing-cisterns of cast iron, each divided into seven water-chambers, was in readiness for trial. With only two cisterns of the ten, 371 pounds of ice were made in eight hours. The water employed for condensation was thirty times in quantity the water frozen. In the vacuum-vessel the tension of vapor began with 5.7 inches of mercury and ended with 2.7 inches. In the condenser, the tension rarely exceeded 2 pounds above the atmosphere. The pump was 8½ inches bore and 18 inches stroke, working 90 double strokes per minute. On the 2d of March, 1855, 661 pounds of ice were made in eleven hours and ten minutes with only four cisterns. In different trials during the summer, eight cisterns of the ten were put on. The machine would at any time freeze up in these cisterns 56 cakes of ice, each 1 foot square and 6 inches thick, and weighing together 1,680 pounds. With ten cisterns, a ton could be frozen.

The great merit of Professor Twining's invention was extending the surface over which ice could be formed, by extending the "freezing-cistern" containing the ice-moulds, and using an uncongealable liquid which was stagnant around the moulds. This was the great advance on Mr. Jacob Perkins. In a patent issued April 22, 1862, he claims a pump to agitate or circulate the uncongealable liquid. Twining described in 1852, but a patent was only issued on the 15th of April, 1862, the method of using a refrigerator, as in the Harrison machine, with vertical tubes closed beneath or entering a *cul de sac*, allowing the ether to run down and its vapor to escape upward. The vaporized liquid thus abstracts heat from a contiguous uncongealable liquid that surrounds the pipes, and in its cold state is drawn out by a circulating-pump in place of running the cold volatile liquid through the freezing-cistern. This pump circulates the brine in open troughs which contain the water-vessels. Professor Twining aimed at extending surfaces, and for this he had described a *percolator*. He had perforations, or perforated branches or channels, girdling every exposed side of each *water-chamber*, and made to inject the ether in jets, or drops or films, upon or between its exposed surfaces or coatings. The volatile liquid thus spread upon or running down the water-chambers freezes through the *uncongealable liquid* and the *water-vessels* in those chambers.

Mr. James Harrison, of Geelong, Australia, did excellent work in his investigations of this subject, and so instructive are his specifications that they may be said to constitute the most substantial contributions to

our knowledge of ice-machines at the dates they were respectively published. In his patent, No. 747, dated March 28, 1856, Mr. Harrison tells us that he employs "an air-tight apparatus of three vessels connected by tubes; a vacuum is to be established throughout the apparatus, the air being expelled by the vapor of ether, alcohol, liquid ammonia, or other volatile liquid." Mr. Harrison, so far, adopted Mr. Perkins's plan of obtaining space for his vapor, since the latter recommended filling his machine to repletion, and then taking some, say half, out to make room for vapor. It is quite clear, from the perusal of Mr. Harrison's patent, that the machine was designed to freeze by evaporation of ether, for the alcohol and the liquid ammonia, the latter universally known as a solution of gaseous ammonia in water, would have been of no avail whatever in the apparatus so well described. Indeed, the words, "liquid ammonia or other volatile liquid," inserted at the beginning of his specification, would have required the description of various forms of apparatus made of different materials, for the copper would have been destroyed by the liquid ammonia; and the vague expression, "volatile liquid," he extends to water in his claim, and we well know that had he tried water in the machine he describes, it would have been inoperative. This meaningless attempt to grasp everything, without knowing more than that part of his subject relating to ether, is the main defect of this important contribution to industrial art. He goes on to say:

"The nature of my invention consists in producing cold, by the evaporation of a liquid in one vessel, the withdrawal of the vapor formed, and the getting rid of heat thus withdrawn by the condensation of the vapor in another vessel." . . . "The evaporating-vessel may be of tinned copper, or any air-tight and water-tight material of good heat-conducting power, capable of resisting the atmospheric pressure, and not acted upon by the substances in contact with it, and of any shape, provided there be a sufficient surface of contact respectively to the liquid to be evaporated and the substance to be cooled. In like manner, the condensing-vessel may be of any material and shape, the requisites of strength, conduction of heat, resistance to chemical action, and sufficient surface being attended to." Having described his pump, &c., and referred his readers to their knowledge of heat to supply the data for practical work, he enters into definite calculations bearing on the use of ether. He says: "The requisite surface of the evaporating-vessel may be deduced from the ascertained fact that a surface of 10 square feet will evaporate fully 1 pound of water per minute, with a difference of temperature of 30°; with a less difference, a proportionately larger surface will be required. The latent heat of other liquids being less than that of water, a less surface will suffice for their evaporation. For instance, the latent heat of ether at, say 24°. is to that of steam at 212° as 200 to 1,000, nearly; therefore only one, fifth of the surface, or one-fifth of the difference of temperature, will suffice for the evaporation of ether. The same rule will apply to the

59 F

condensing-vessel, but as no loss except of space can accrue from having the vessels much larger than is by calculation necessary, it will be well to make them of ample capacity and surface."

Mr. Harrison aimed at establishing a broad claim which he stated as follows: "Having thus described the nature of my invention, and the manner of performing the same, I would have it understood that I do not confine myself to the arrangement of apparatus described, but what I claim is, the use of volatile liquids (including water), evaporated *in vacuo*, and reduced to the liquid form in a separate vessel by pressure, for the production of cold, and in the manufacture of ice and generally in all processes where refrigeration is requisite or desirable."

In the month of September, 1857, Mr. Harrison applied for a second patent in which he gave a description of the tinned copper ice-moulds which were used until superseded by Telier's metal plates, and he recommends a great number of moulds to give ample conducting surface, because ice is a bad conductor of heat, and in proportion to the slowness of conduction must the cooling surface be increased. He goes on to say at the end of his patent that "having described the nature of my invention and the manner of performing it, I now proceed to ascertain the points in which it differs from the more general description of the power of refrigeration, by the continual evaporation and condensation of volatile liquids *in vacuo* given in the specification of my patent, No. 747, 1856. I have herein described two new refrigerating-vessels, viz, a tubular boiler, and a series of vertical plates separated by wires, and two new forms of condensers, viz, a coil of tubes connected with a central cylindrical vessel, and a vertical tubular condenser combined with a similar cylindrical vessel."

"I am aware that the employment of saline solutions for carrying frigorific power has been frequently proposed, but the economical use which I make of this agent is not so much for the mere transmission as for the diffusion of this power over a large surface, the necessity for which I have ascertained by original experiments on the conducting power of ice."

"My invention, as now perfected, consists in the combination of a refrigerating process by the continued and self-regulated circulation of a stream of ether, or other volatile liquid, with the continued stream of uncongealable liquid, conveying and diffusing the frigorific effect over large surfaces, and in rendering the process subservient to the manufacture of ice on an economical scale, to cooling worts, &c., to regulating the temperature of apartments, and generally to any process in which a temperature below that of the season or climate is required."

Harrison's ether-machine, constructed with great precision and good workmanship by the late Mr. Daniel Siebe, proved at once the best practical machine for making ice, and the first one was taken to Melbourne, where it was recently, if it be not still, at work. This form of machine has been well made by Messrs. Siddely & Mackay, of Liverpool; and

there are places in Ceylon, Java, the East and West Indies, and Australasia where ice is so dear that an ether machine may work at a profit, although making little more than one or two tons of ice per ton of coal burned. The Messrs. Siebe, in conjunction with the late Mr. King, engineer to Messrs. Truman, Hanbury & Co., brewers, London, introduced the Harrison machines with conspicuous success, for the direct refrigeration of water used in brewing, and it was owing to this that I first used one for cooling meat in 1869, and afterwards made several modifications in their construction.

The greatest improvement in ether machines must be credited to Ch. Tellier, for by the introduction of methylic ether, patented in America on January 5, 1869, he avoided a vacuum in his refrigerator, and this both in the sulphuric-ether and sulphurous-oxide machines (especially working at low temperatures) is attended with the introduction of air into the interior of the machine. Air decomposes these agents, but whilst its action is slow in effecting a chemical change, it is instantaneous in modifying the tendency to gaseous liquefaction. A little air mixed with the volatile vapor will soon make a difference of many pounds on the square inch in the condenser and the efficiency of the machine is greatly reduced. M. Tellier lays much stress on the value of his congealer, which is another part of his patents infringed in all the ice-box patents devised. It practically amounts to a box divided into compartments by hollow metallic walls, in which the methylic ether is evaporated. The wooden tank is filled with water, and all the compartments are frozen when the ether is evaporated. This was done to supersede movable moulds, as in Twining's and Harrison's patents, and to avoid the waste and labor of lifting the moulds and dripping the uncongealable brine or other liquid used in the machine.

The pump and condenser of the Tellier machine are adapted to such pressures as are required for the condensation of this ether, which boils at 30° below 0 Centigrade. The pressures in the condenser amount to 45 pounds at 60° Fahr.

I regret that I have not by me Tellier's work on Ammonia. To Ch. Tellier is due the credit of the introduction first of the aqueous ammonia in the *absorption* or *distillation* freezing-machines, and afterwards the anhydrous ammonia liquefied by mechanical compression. M. Ferdinand Carré worked in conjunction or simultaneously with Tellier, and the circumstances under which M. Carré obtained the first patent for liquid ammonia, gave him control of the absorption-machines. A keenly-contested suit for infringement led to Carré's rights being sustained, and it is generally understood that he obtained 3,000,000 francs for his patents, which date back to 1862. Professor Barnard has furnished us with an elaborate report on the Carré continuous freezing apparatus. So fascinating was the apparatus as exhibited in 1867, in Paris, that Professor Barnard declared it to be "one of the most valuable contributions which science has yet made to the promotion of human comfort, and to the

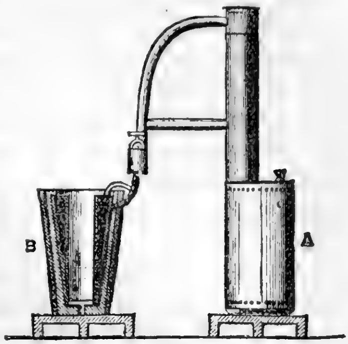
progress, in certain forms at least, of industrial art. Indeed, when the apparatus is examined in its details, and the ingenious felicity with which the difficulties involved in the problem have been met is understood and appreciated, this invention cannot fail to be recognized as presenting one of the most admirable illustrations of the combination of scientific knowledge with practical skill which the Exposition presented."

A solution of ammonia is introduced into a boiler which is heated by a furnace to about half its altitude. A tube extending upwards conveys the liberated ammoniacal gas to a vessel called the *liquefier*. The upper part of the boiler is occupied by broad shallow vessels pierced with holes, constituting the *rectifier*, so as to return the water to the boiler whilst allowing the escape of the gas. The gas passes to the aforesaid liquefier, which is a combination ot zigzag and spiral tubes in a tank of cold water, and thence into a kind of bin where, under a pressure of 150 pounds at 70° to 80° Fahr., the gas is liquefied. From here the ammonia flows into a small receiver adjoining the refrigerator, and which is called the *distributor*. Thence the liquid passes into zigzag or spiral tubes forming partitions in a tank, and between which the substances to be cooled are placed. These tubes of the refrigerator converge into the *collector*, which is a horizontal tube, from which an ascending pipe returns the ammonia rendered gaseous by heat to a vessel, *the absorber*, partially filled with water, and which greedily absorbs the gas; a current of cold water passes through a coil in this vessel. This water has also to cool the spent liquor from the boiler and which is to reabsorb the gas. When the gas has been reabsorbed, the strong solution is forced by a pump into the boiler.

Taking a machine with a production of 400 pounds of ice per hour, it must distil, liquefy, evaporate in the refrigerator, and redissolve 80 pounds of pure ammonia. The 80 pounds of ammonia with 1,600 pounds of water give 1,680 pounds of liquid to be acted on. This liquid is at first at 62°.6 Fahr., but in work the supplies return to the boiler at or above 140° Fahr., so that for continuous work 1,600 pounds of water have to be raised from 140° to 266° Fahr., or through 126 degrees, and also to convert 80 pounds of pure ammonia from 140° Fahr. into vapor at 266°. The consumption of fuel has been computed in practice at 50 pounds per hour, each pound making eight pounds of ice; besides this, the fuel for the steam-engine has to be supplied, and in most cities the water has to be paid for. That water Professor Barnard calculated at 3,200 gallons per hour, or nearly one gallon per second, making less than five tons of ice per day. Many attempts have been made to improve these machines since by Oscar Kropf, Rees Reece, Martin, Beath, Nishigawa, and others. With condensing and absorbing coils in which water is showered whilst air blows across to favor evaporation, a great economy in water is effected; but the pressures and leaks in these machines are very objectionable, the construction is complicated, parts numerous, and the dehydration of the ammonia is always so far from perfect that it in-

terferes with the efficiency of the machines. They have been useful in temperate climates, but have failed almost universally in those hotter countries where their immense value was anticipated as a certainty.

Carré's intermittent ammonia apparatus has been described in the fewest possible words by Messrs. Roscoe and Schorlemmer, from whose book, through the kindness of the Messrs. Appleton, we have been favored with the annexed illustration. The apparatus consists of two strong iron vessels connected by a vent-pipe of the same metal. The cylinder (A) contains water saturated with ammonia gas at 0°. When it is desired to procure ice, the vessel (A) containing the ammonia solution is gradually heated over a large gas-burner. The ammonia gas is thus driven out of solution, and as soon as the pressure in the interior of the vessel exceeds that of seven atmospheres it condenses in the double-walled receiver (B). When the greater portion of the gas has thus been driven out of the water, the apparatus is reversed, the retort (A) being cooled in a stream of cold water, whilst the liquid which it is desired to freeze is placed in the cylinder (D), placed in the interior portion (E) of the hollow cylinder. A reabsorption of the ammonia by the water now takes place, and a consequent evaporation of the liquefied ammonia in the receiver. This evaporation is accompanied by the absorption of heat which becomes latent in the gas. Thus the receiver is soon cooled down far below the freezing-point, and the liquid contained in the vessel (D) is frozen.



Messrs. Alexander Carnegie Kirk and George Thomas Beilby, of Scotland, obtained provisional protection, but afterwards abandoned their invention, which consisted essentially in placing a suitable solid substance in the absorbing-vessel instead of a liquid, as heretofore employed, for the purpose of absorbing the vaporized ammonia. The absorbent may consist of charcoal, or of chloride of silver, or of chloride of calcium, or of any solid substance having, like these, properties of absorbing large quantities of vaporized ammonia at ordinary temperatures and of giving off such ammonia again when heated to an extent short of fusing the said solid substance.

In order to prepare the apparatus for a fresh operation the absorbing-vessel is subjected to a sufficient heat in any convenient way; the evaporating-vessel being then kept cool, the ammonia is, by the heat, driven from the absorbing-vessel and is liquefied in the evaporating-vessel; the absorbing-vessel is next cooled and reabsorption takes place in it, whilst the ammonia is evaporated in the other vessel and produces the cold desired. Both the ammonia and the absorbent employed must be as free from water as possible.

This amounts to a substitution of a solid substance for the water in Carré's intermittent apparatus, and its efficiency is less, owing to the smaller quantity of ammonia which can be operated on in the same apparatus. "A given quantity of chloride of silver would produce only about the thirtieth of its bulk of liquid ammonia, and a fifth part of its bulk of ice at 0° C. In order to produce a kilogram of ice, it would be necessary to employ $27\frac{1}{2}$ kilograms of the chloride; and this supposes the operation to be conducted with no loss. Water, on the other hand, dissolves, at moderate temperature, seven hundred times its volume of the gas, a quantity capable of producing two-thirds of its bulk and half its weight of liquid ammonia, and of converting into ice more than three times its own bulk. A kilogram of water employed as a solvent of ammoniacal gas will thus suffice to produce three kilograms of ice." (Barnard.)

M. Ch. Tellier covered by patents, in France and England, an invention which he afterwards patented in America on the 8th of March, 1870, and which has proved, especially by the action of a host of infringers, to be the most ready and economical plan of taking advantage in a refrigerating apparatus of the unequalled heat-absorbing power, at moderate pressures, of the volatilization of a liquid. His claim is for "the use or application, for the purpose of generating artificial cold, of pure ammoniacal gas liquefied by means of mechanical compression, substantially as described." He used the pump and condenser described in letters-patent 85,719, issued January 5, 1879; and while Tellier has continued to give the preference to methylic ether in France, this has been simply due to the greater facilities for pumping this ether. The benefits to be derived by the use of anhydrous ammonia have failed of being realized, owing to the practical difficulties of pumping it by reciprocating-pumps—difficulties which are only in a lesser degree experienced, but nevertheless encountered, in pumping other volatile agents.

In the month of May, 1877, M. Tellier issued a circular in which he propounds the merits of a new absorption machine for the use of trimethylamine in producing cold. The apparatus is similar to the ammonia-*absorption* machine, and here Tellier remarks that, without renewing the strife of seventeen years previously, he has a right to use his own invention, patented on the 25th July, 1860, as against Carré, whose patent dated 24th August, 1860, both patents being now public property.

Trimethylamine is a peculiar ammoniacal compound—a crude organic ammonia in a sense, contained in large quantity in herring-pickle, and to this it gives its peculiar odor. It is, like all agents of great value as refrigerants, readily soluble in water, and boils at 49°.6 Fahr. Moderate heat, such as that of exhaust steam, readily distils it, and the pressure in the liquefier amounts to about one atmosphere. Mr. Camille Vincent, a distinguished chemist, conceived the idea of treating in close vessels the residue of the distillation of molasses, and from this residue he has obtained an abundant supply of trimethylamine. It is not a little remark-

able that this new method of producing ice for next to nothing, according to M. Tellier, was not exhibited in Paris during the recent Exposition, but as the last invention of one of the most fertile brains devoted to the study of artificial refrigeration, I have deemed it right to give the drawing and description from Tellier's British patent which has recently reached me.

He describes his improvements as follows:—

"Firstly. In employing trimethylamine, methylamine, ethylamine, or other analogous volatile products which boil at a very low temperature (about 8° or 10°), and which are soluble in water or other liquid.

"Secondly. In vaporizing one of these products for the purpose above described either by means of the heat of escape steam from a steam engine, or by means of any other suitable source of heat.

"Thirdly. In so combining and arranging the apparatus employed for this purpose as to use only a limited quantity of the refrigerating body, and to produce a current of air, gas, or uncongealable liquid carrying the cold to the place and for the purpose desired.

"For this purpose I cause the escape steam which is to be condensed, or, in short, the source of heat which I wish to utilize, to pass into a tubular boiler, preferably containing a solution of trimethylamine in water. The trimethylamine vapours, after having been washed in a concentrated solution of trimethylamine, are forced to pass through one or more worms, where they are liquefied. The liquid product is collected in a reservoir, from whence it falls in a shower, from top to bottom, into an apparatus or case containing a series of tubes enclosing a gas or an uncongealable liquid moving from the bottom upwards. The trimethylamine is vaporized in cooling the fluid in the tubes, which is then directed to cool the bodies, the temperature of which it is wished to lower.

"In order to utilize the trimethylamine vapours thus produced I can condense them by means of a compressing pump, but I prefer to effect this condensation by means of the water which contained these vapours at the commencement of the operation, and from which the application of the heat separated them. For this purpose the said water is cooled and conveyed to an apparatus or case into which also the trimethylamine vapours enter. The solution of these vapours in the water will be effected under the action of a current of cold air passing in the tubes which traverse this apparatus or condenser.

"The first solution being thus reconstituted is discharged at the outlet into the tubular steam boiler, heated by the lost vapours or otherwise, after having passed through an apparatus where it is reheated in cooling the drained solution, which is directed towards the condensing apparatus of the trimethylamine vapours. In this manner any given quantity of this liquid may be used over and over again indefinitely.

"But to make the invention better understood, I will proceed to de-

scribe the same by reference to the accompanying Drawings, in which Figure 1 shews one of the arrangements which may be employed.

"A is a steam engine of any suitable construction. The escape steam which it produces is conducted into a condenser, shewn at B, and the form of which may vary; and instead of being filled with water this condenser contains a solution of trimethylamine, obtained as hereinafter described.

"Under the effect of the heat which the condensed water steam gives off, the solution of trimethylamine is decomposed, and the trimethylamine itself being vaporized, escapes by the conduit pipe *b b*.

"As gases which separate from their solutions always carry away some water steam, and as it is necessary in this case to have the trimethylamine as pure as possible, the vapours which escape from the condenser B are rectified in the rectifier C, which contains the richest solution of trimethylamine. For this purpose the tube *b b*, is inflected in such a manner that, being doubled round on itself, it may be spread over the whole of the lower part of the rectifier C at *z*, *z*. Under these conditions the trimethylamine vapour bubbles in the strong solution contained in the rectifier C, and the vapours which escape therefrom through the tube *c*, *c*, will be found to be sufficiently pure.

"It should be remarked that it is requisite that this operation should be as complete as possible, and it may therefore be necessary to add one or more rectifiers, or to replace them by a rectifying column similar to those employed in the rectification of alcohol.

"To conclude with this part of the apparatus, the trimethylamine solution constantly arrives by the tube *a*, *b*, travels over the whole of the rectifier, escapes by the tube *a*, *c*, *a*, *c*, to run over the whole length of the condenser B, and finally escapes by the tube *a d*, which conducts it into the float space D, which allows of its expulsion.

"It will be readily seen that under these conditions a water level is no longer required, and that, just the spaces being filled with solution, the quantity of saturated methylhlamine which arrives by the tube expels (in consequence of the general falling back of the solution communicating itself to the condenser B) an equal part of spent solution through *d b*.

"The trimethylamine vapour which escapes by the tube *c*, *c*, enters a condenser E, consisting of a worm or coil *e*, *x*, round which circulates a current of water entering at *e*, *a*, and egressing at *e*, *b*.

"From the effect of the light pressure which is produced by the ebullition of the trimethylamine solution, a relative amount of cold is produced by the current of water, hereinbefore described, around the worm or coil *e*, *x*, *e*, *x*, and the trimethylamine is condensed; thus condensed, it escapes by the tube *e c*, which causes it to pass through a worm or coil *f*, *f*, *f*, placed in a receiver F, the object of which is hereinafter described. Finally, it is conducted by the tube *f*, *a*, to a float receiver G, which, when it contains sufficient liquid, allows the solution to escape

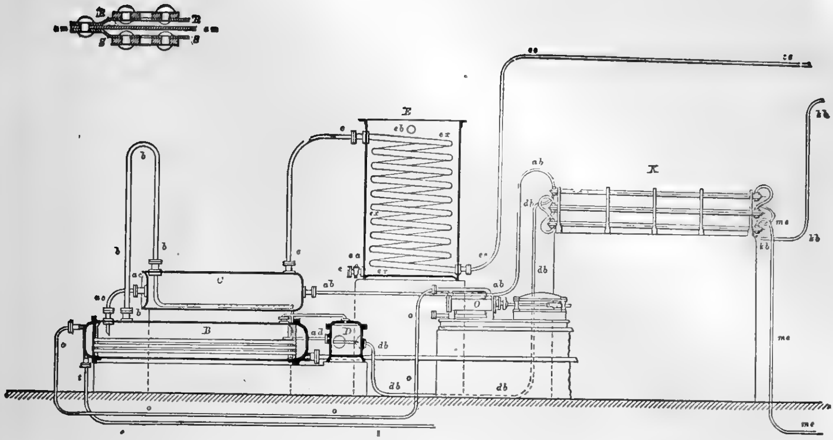


FIG. 1.

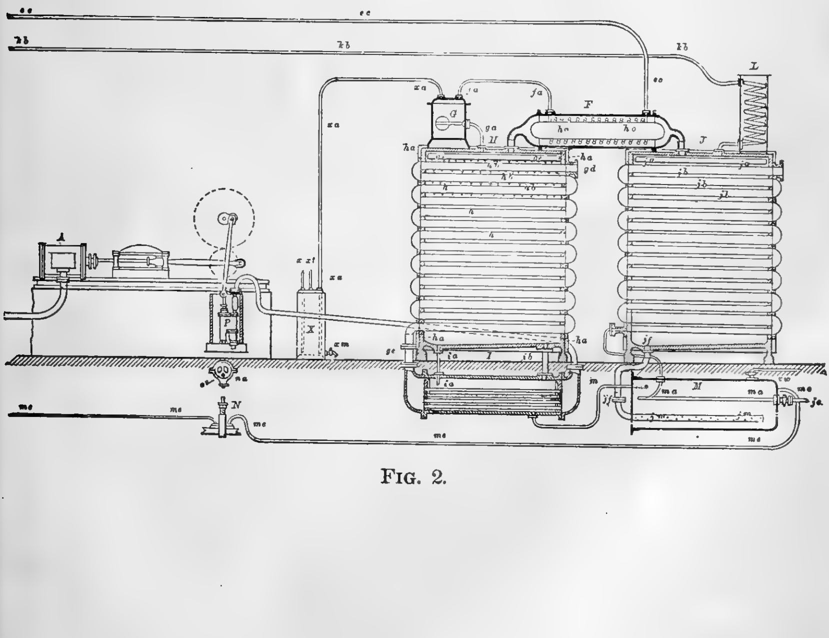


FIG. 2.

by the tube *g*, *a*, and consequently it arrives in a large rectangular space H, which is nothing but a refrigerator.

"Before further describing this refrigerator I will describe the use of the float space G.

"The trimethylamine is condensed at about 10°. Running water having generally a temperature of from 10° to 28°, according to the climate and seasons, a slight pressure over that of the atmosphere will be necessary to effect its condensation, and afterwards a pressure such as that already described in the condenser E. On the other hand, as cold is to be produced, that is to say 12° to 15° below zero, it is necessary to have a certain vacuum in the apparatus in order that the trimethylamine may be vaporized. It is to allow these two phenomena to be produced simultaneously that the float space G is employed, which puts a barrier between the two of them.

"The arrangement of the refrigerator allows of producing cold methodically, that is to say, to cause the purest trimethylamine to arrive on the coldest surfaces in such a manner that the energy of the vaporization remains constant.

"The refrigerator consists of a rectangular cast-iron frame *h a*, *h a*, *h a*, *h a*, provided with a flange on each side, which allows of tightly closing it by means of two plates of sheet iron held by a suitable number of tie pieces and nuts. Throughout its height it is furnished with a certain number of tubes *h*, *b*, which are joined together at their ends by elbows joining them together two and two, thus forming one continuous pipe.

"If a current of uncongealable liquid (solution of chloride of calcium or other suitable solution) be thrown into this tube at its lower part by the tube *g*, *c*, this current will rise through all the tubes, and finally egress by the tube *g*, *d*; meanwhile the liquified current of trimethylamine enters by the tube *g*, *a*; this liquid runs into the trough *g e*, *g e*, which distributes it through the whole length of tubes *h*, *h*. The trimethylamine deposited by the points, with which the under side of the tubes are furnished, runs over the periphery of the first tube, then that of the second tube, and so on for the following tubes, and constantly vaporizing, thereby constantly produces cold, but in so doing is impoverished, for the water which it draws with it does not vaporize; on the contrary it increases the solution in proportion as its advances and paralyses the vaporization.

"To withdraw all that part of the trimethylamine that may vaporize when this liquid arrives at the lower part of the refrigerator H, it is discharged by the tube *i a* into a tabular receiver I, which is in fact a vaporizer, in the tubes of which circulates the current of chloride of calcium which has been to convey the cold, and in consequence is there at its highest temperature. Under the effect of this temperature, proportionately raised, the last possible vapours of trimethylamine escape; they are conducted by the tube *i*, *b* into the refrigerator H, where they are reunited with those which are already formed there. But in order that

the operation may continue, the vapours must be removed as fast as they are formed. To effect this they can be absorbed by a current of water

"It is preferable to abstract a current of spent solution from the boiler, and to conduct this current into the apparatus shewn at J, in which the vapours may be absorbed. This apparatus is exactly similar in its general arrangement to that shewn at H, and is in free communication with the same, by means of the vessel F and its two tubes *h* and *j*, consequently the vapours which are formed in H arrive freely in the apparatus J. To absorb them, the spent solution coming from the vaporizing condenser B is conducted into the gutter *j a*, *j a*, and to the passage of which I will hereinafter refer. This gutter, perforated similar to the gutter *g e*, *g c*, with a multitude of holes, discharges over the length of the top tube *j b* the solution from the first tube; it falls on to the second, and so on, thus offering a very large surface for the absorption of the vapours which arrive from the apparatus H. But to effect this absorption it is not sufficient merely to offer the absorbing surfaces to the gas to be absorbed, it is necessary that the liquid should be cold, and moreover that the heat produced by the condensation of the trimethylamine vapours should be carried off, the absorption being in direct proportion to the temperature. To obtain this double result the spent solution which escapes from the float vessel D is caused to pass through the tube *d*, *b*, *d*, *b*, *d*, *b*, through an apparatus shewn at K, which may be called an exchanger, and the action of which is hereinafter described. At the outlet *k*, *a* of this exchanger the solution escapes by the tube *k*, *b*, *k*, *b*, which conducts it to a worm L, which, constantly surrounded with cold water, effects the cooling of the said solution, which then enters the apparatus J at a temperature identical with that of the water which was employed to cool it in the worm L.

"With regard to the caloric which is disengaged during the condensation of the trimethylamine vapours in the absorber J, it is carried off by a current of water, which is caused to arrive by the cock *j*, *c*, and which, running through all the tubes *j b*, *j b*, *j b*, carries off the caloric as fast as it is formed.

"To assist the distribution of the liquids over the changer from H and J, they may be coated with a light tissue of cotton netting.

"Should water be scarce in the country where the apparatus is working, the water which has been used in the absorber J may be used for the condensation in the condenser E, which is a very important consideration. Only slight excess of pressure in the trimethylamine generating apparatus will result from this state of things, and consequently it is always easy to set them up.

"Referring again to the absorption, a portion of the vapours will have been able to escape at the condensation. To avoid this inconvenience the vapours and the condenser liquid which has been used in the absorber J are caused to descend through the tube *j f*, *j f*, which conducts the whole into M.

"It will be easily seen that the whole arrives through the whole length of M by the perforated tube *j m*, *j m*. The combination will thus be effected under the best conditions, which are still more favoured by the current of cooling water, which, entering at *j c*, first runs over the surface of M through the worm *m a*, *m a*, before entering the tubes of the absorber J, and here the production of the solution which was to be formed is finished.

"As will be easily understood, it is necessary to carry it out of the absorber, and cause it to give back the trimethylamine, which should again produce the freezing action, and thus render it permanent.

"To obtain this latter result it must be reconducted to the vaporizing condenser. For this purpose the tube *m c*, *m c*, *m c*, *m c*, passes from the absorbing vessel M to the said vaporizing condenser. By following the course of the tube *m c*, *m c*, *m c*, *m c*, it will be seen that instead of going direct to the vaporizer B, it is at first drawn in by the pump N, which is necessary, since there is only a very low pressure in the absorber J, and a higher pressure in the vaporizer B, and that moreover it is caused to pass through the series of plates of the changer K; and I will now describe this apparatus.

"It has been seen that very hot liquid was sent out of the vaporizing condenser B, and that, on the contrary, very cold liquid was discharged from M, and which should be returned into the vaporizer B. It is then requisite to exchange the temperatures, that is to say, to impart the heat to the liquid which is to enter the vaporizer B, and the cold to the liquid which is to enter the absorber J, and it is for this purpose that the exchanger K is employed. It consists simply of three plates of sheet iron united together at their peripheries by one or two rows of rivots. This arrangement is shewn in Figure 2, on a preceding page.

"The plate *a m* is the exchange plate.

"In the space R, R, circulates the liquid to be reheated, which may escape through the tube *r m*; in the space S, S, on the other hand, comes the liquid which is to impart the heat.

"As will be easily seen by referring to K, the two liquids run in opposite directions, and consequently exchange their heat. The liquid which enters the rectifier C by the tube *a b*, *a b*, is as hot as possible; and that which leaves by the tube *k b*, *k b*, and enters the absorber J after having run through the worm L, is as cold as possible.

"It remains to describe some of the parts which are necessary to insure the working of the apparatus. These consist of six pumps placed round the steam engine A, viz:

"1. An air pump, shewn at O.

"2. Another similar air pump placed behind the pump O, and on a level with it, and is consequently not seen in the Drawing, but which I will call pump No. 2.

"3. A chloride of calcium pump P.

"4 A feed pump N, moved by an excentric *n a*, keyed on the shaft Q.

"5 A pump similar to the chloride pump, but placed at the opposite end of the shaft Q; this pump is not seen in the drawing, but it shall be called pump No. 5.

"Another feed pump similar to the pump N, not seen in the drawing, called pump No. 6.

"I will now describe the working of these different pumps.

"The pump O is used for withdrawing, by means of the tube *o*, *o*, *o*, *o*, the air brought by the water steam into the tubes of the condenser B, and therefore insures the proper working of the same.

"The pump No. 6, identical in its action to the pump N, takes, by means of the tube *t*, *t*, *t*, the condensed water in the condenser B, and conducts it into the boiler, which furnishes the steam to the cylinder of the engine A, and which may be placed in any suitable position.

"The pump No. 2, which is an air pump similar to the pump O, draws in through the tube *v* all the air which may be in the apparatus J and H; it therefore allows the trimethylamine which arrives there to evaporate at low pressure and carries off at the same time the air which by chance might enter into the apparatus. A cock placed at *v w*, allows of regulating this action, as will be understood. The pump No. 2 may be so fixed that it may be disconnected when required. As the air which it draws in is charged with methylamine, it does not send it directly into the atmosphere, but into a receiver containing water, and in which the trimethylamine may be absorbed. This receiver is shown at X. As will be easily seen, it is provided with three tubes, one at *x*, which communicates with the pump No. 2; one at *x a*, which communicates with the purifier; and one at *x t*, which communicates with the interior. Finally, a cock *x m* allows of drawing off the saturated liquid.

"The working of the chlorure pump P has been hereinbefore described.

"With regard to the pump No. 5, it draws up water from any suitable source, and raises it into the upper reservoir to distribute it either around the condenser E, or round the cooler L, and finally in the absorber J, to be employed in the absorption.

"The motive power furnished by the cylinder engine A needs no description; it is used in the ordinary way.

"The current of cooled chlorure of calcium which escapes through *g*, *d* may he utilized for producing ice or cold.

"The operation of the changer K will be readily understood.

"The vapours which escape from H through *h* are very cold, but the trimethylamine which runs through the worm *h o*, *h o*, is slightly warm, thus causing them to circulate in opposite directions; the greatest amount of cold is extracted to carry it back to H."

P.—AIR-MACHINES.

The opinion has widely prevailed that the simple expansion of compressed air produces cold, and that the effect is analogous to the change

of physical state from the liquid to the gaseous. Joule originally declared that *no change of temperature occurs when air is allowed to expand in such a manner as not to develop mechanical power.* Later experiments by Joule and Sir William Thomson indicate, nevertheless, a slight cooling effect.

Some remarkable natural phenomena are attributable, however, to conditions under which air may be compressed and forced through obstructions, so that its heat may be transformed into mechanical energy, and thus it cools wells or actually freezes water in subterranean caverns. The frozen well at Brandon, Vt.,* has been examined by Prof. John M. Ordway, and is an interesting example of this description. Cold air is constantly flowing upward in it. At the opening of the well the thermometer indicated 43°.5 Fahr., the temperature of the external air being 78° at the time of the examination. Five feet below the mouth, the thermometer stood at 43°, and 12 feet down, at 40°. Water drawn out from the bottom without stopping to cool the bucket was at 34°, and at other times it contained lumps of ice detached from the ice-coating lining the well for some 5 feet above the surface of the water. Professor Ordway says: "We had hardly begun to make close observations before it occurred to us that we were dealing with a case of compressed air, which might be accumulated by some natural subterranean tromp (Wassertrommel) or "Catalan blower," and which passing through the gravel effects the gradual refrigeration and actual freezing of a considerable quantity of wet gravel."

To Dr. John Gorrie (American Journal of Science and Art, vol. x, page 39) we owe the earliest determinations of the quantity of heat evolved from atmospheric air by mechanical compression with a view to the production of ice by machinery. He directed attention to the discrepant statements of Colladon, Gay-Lussac, Dalton, and others, and having secured the coöperation of capitalists for the erection of air-compressing appliances in New Orleans, he chanced to adopt the only method by which any success, by this method, in artificial refrigeration was possible. The compressed air was allowed to discharge into an engine which worked expansively through a valve so constructed as to permit of cutting off the communication with the reservoir at any portion of the stroke. The air, in this way, independently of the safety-valve, was prevented from attaining more than a certain degree of pressure. Dr. Gorrie anticipated later patents in which the injection of water to cool the air in the compressing-pump has been practised. Indeed, he studied the subject with skill and in a true philosophic spirit, complaining that "owing to defects of mechanical contrivance and unskilful workmanship, incidental, perhaps, to every new device and a novitiate intercourse with practical mechanics, the machine was not capable of performing all its duties with the accuracy the natural laws involved called for."

---

* Ann. Sci. Discoveries, 1856, p. 190; 1860, p. 316.

It is foreign to my purpose to quote the tables and experiments relating to the differences in temperature between the air and the water at their influx and egress; but a crucial experiment which he performed was conclusive and interesting: "During an experiment of an hour's duration the water of injection, instead of being supplied, as usual, by the city hydrant, was taken from and returned to a butt of about 130 gallons capacity, containing about 1,100 pounds of water. At the commencement of the experiment the temperature of the water was 77° Fahr. (the atmosphere being 79° Fahr.); at the end it was 112° Fahr., the engine working twenty revolutions a minute. The quantity of ice which the heat thus disengaged would melt is equal to ($1100 \times 32 \div 140 =$) 275 pounds; or for 24 hours, 6,600 pounds. There was but very little diminution in the rate at which the temperature of the water was increased.

"The quantity of heat which the condensed air in its expansion is capable of absorbing, or, in other words, the quantity of ice it is capable of producing, proves that there has been no material error of observation or calculation.

"The quantity of heat generated by compressing air to half its volume is sufficient to elevate the temperature of an equal weight of water 74° Fahr., and of its own body 277° Fahr. When it was reduced to one-fourth of its volume, the increase of heat became, for water, 105° Fahr., and for air, 395° Fahr.; and when condensed to one-eighth of its original volume, the heat was, for water, 125°, and for air 472° Fahr.

"According to these observations and deductions, while the densities of air increased in the geometrical progression 2, 4, 8, the heat evolved corresponded nearly to the arithmetical series 3, 4, 5. But the ratio in the differences of temperature between the assigned densities follows a very different rate of progression from either: thus, for the densities 2, 4, 8, atmospheric pressure, the corresponding differences of heat evolved were, in the decreasing number, nearly (277, 118, 80) 3.5, 1.5, 1."

I need not further refer to Mr. C. W. Siemens's idea of compressing air and expanding it in an engine as noticed elsewhere. Mr. Alexander Carnegie Kirk was the first and most successful inventor of a practical air-machine for making ice. He wished to supersede an ether-machine at the Bathgate Paraffin Works, owing to its being too small and dangerous. He had to cool the oils to a temperature of from 35° to 40° Fahr., to crystallize the paraffin. On his first trial air was compressed into a receiver and allowed to expand by driving a small engine—a plan which had been proposed and tried—but it offered little encouragement. The next trial was with an apparatus similar to Stirling's air-engine, with which, after many modifications, mercury was frozen. Mr. Kirk designed a machine, patented on the 25th April, 1862, for the application and use to and in the production of cold of a vessel containing air or other elastic fluid or gas alternately in a state of compression and expansion, and provided with a piston and regenerator. On the piston being moved to one end of the vessel, the enclosed air may pass freely to the other end, giving out its heat to or absorbing heat from the regenera-

tor as it passes through it. The piston is caused to move in such a manner that the air whilst being compressed will always be at one end of the vessel, and whilst being expanded be always at the opposite end of the same, the regenerator preventing the conveyance of heat or cold by the air from one end of the vessel to the other. The heat generated during compression is removed by exposing that part of the vessel to a current of cold air, water, or other cooling medium, whilst the cold produced at the other end by expansion is used to refrigerate any liquid or substance which may be brought in contact therewith.

Mr. Kirk afterwards found an advantage in using damp air instead of dry air, and in his paper on the Mechanical Production of Cold, read in 1874, before the Institute of Civil Engineers in London, he established the following comparison:

In dry-air machine:

Indicated horse-power, 7.08.

Rejected heat = 1,409 pounds of water heated 1° Fahr. per minute.

Absorbed heat, 1,106 pounds of water cooled 1° Fahr. per minute.

In wet-air machine:

Indicated horse-power, 7.8.

Rejected heat, 2,271.2 pounds of water heated 1° Fahr. per minute.

Absorbed heat, 1,795.2 pounds of water cooled 1° Fahr. per minute.

The professed improvements of Messrs. Windhausen, of Germany, and Paul Giffard, of Paris, relate to matters of detail of secondary importance, and it is well recognized now that where water-power can be had and condensing-water is abundant, a cold-air machine may be used, but it is much too cumbersome and wasteful for such purposes as have recently been suggested for ice-machines in steamers for the transport of provisions or for sanitary purposes.

Q—GAS ICE-MACHINES OF NEW TYPE.

The difficulties which I first encountered, with reference to the special object for which I wanted to use artificial cold, were the unsuitable character of absorption (Carré) machines for ships' use; the unwieldy and power-absorbing nature of air-machines; the explosive character of ether-machines.

In dealing with pump-machines such as the Harrison sulphuric-ether and the Tellier methylic-ether apparatuses, the greatest objections I discovered were, the explosive character of the materials, and the quantity of these to be stored in a machine which might leak and distribute a very inflammable gas in a vessel, especially in hot latitudes, where even sulphuric ether is in the gaseous state at atmospheric pressure.

M. Tellier has always spoken of the explosiveness of ether as of secondary importance, and has declared that it is needless discussing the question when alcohols, essences, gases, petroleum oils, &c., are entrusted, to ignorant people and children, under conditions when real danger might be apprehended. But two blacks do not make a white; and the binary

engine of Count du Trembley would have continued running had there not been immense difficulty and peril in using ether in reciprocating engines and pumps.

It occurred to me to introduce a form of condenser and refrigerator consisting of tubes within tubes, as described further on, which reduced the volume of ether, distributed over a wide surface within a narrow compass, and enabled me to construct an apparatus of great solidity and safety. At the same time, one inconvenience attending the ether-machines was that the brine used, common salt and water, was apt to freeze up in the refrigerator-tubes and burst them. This I overcame by the use of an aqueous solution of glycerine, and later on I have economized by using chlorine of magnesium and water, with some glycerine added, according to the temperature at which it is proposed to work.

Without attempting a detailed history of improvements suggested from time to time, my main object for years was to overcome the then inevitable use of a reciprocating-pump in which liquefiable gases were alternately liquefied and volatilized, to the detriment of efficiency. This was found one of the most objectionable features in the use of sulphurous acid and ammonia, inasmuch as a film of liquid remains after every stroke between the piston and the cylinder-cover, and expands on the return stroke so as to interfere with the suction of a fresh charge.

I must enlarge somewhat on this subject of

R.—ENGINES AND PUMPS.

In all freezing-machines, except those depending on absorption of a gas by water and its distillation, it has been a matter of primary importance to secure an economical engine, and a pump capable of producing a vacuum, or compressing a liquefiable gas.

All kinds of engines have been used—upright and horizontal high-pressure and compound engines. The inevitable waste, attending the production of steam, and its imperfect utilization, in the best form of reciprocating engines, have been regarded as really incurable evils, in the production of artificial ice by means of pump-machines.

The method of transmitting power has necessarily attracted considerable attention, and in one machine the crank-shaft has been the seat of all strain, whereas in other cases, with an engine placed on a bed-plate on a line with the pump, the pressure on the engine-piston was greatest when there was least resistance, and *vice versa.*

But the difficulties of the engines, common to all machines using steam, appeared of less importance than the imperfections of the reciprocating pump. Whether single or double acting, the change in the direction of motion at every stroke, the universal clearance or imperfect discharge of the gas from the pump at each revolution; the cumbersome and noisy valves, which are frequently broken by striking; the leaky stuffing-boxes, and the ample surface of the piston-rod, for exposing a layer of gas to atmospheric contact, as many times per minute as the piston runs its

course, led me in early days, when seeking practical improvements in ice-machines, to search for a continuous-motion or rotary pump, without clearance, capable of passing gases of great tenuity, at all pressures.

The obstacles in my way have been well understood by engineers, and I cannot do better than indicate them by a sweeping declaration at page 367 of Professor Thurston's History of the Growth of the Steam Engine. He says: "The rotary engine is gradually coming into use for various special purposes, where small power is called for, and where economy of fuel is not important; but it has never yet competed, *and may perhaps never in the future compete*, with the reciprocating-piston engine where large engines are required, or where even moderate economy of fuel is essential."

I had grown to believe not a little as Professor Thurston expresses himself, when in the summer of 1876 I was told by Mr. Siebe, son of the celebrated Daniel Siebe who first built the successful Harrison ether-machine, that what I had so long searched for had at last been invented by a Lancashire engineer. Mr. Siebe had seen an engine and pump working, in the compression of air, up to 60 pounds, and drawing a vacuum up to 28 inches; and this same apparatus I shortly afterwards purchased from Mr. William Eli Sudlow, the inventor and patentee.

Familiarity in working turbines of various kinds, in connection with cotton and woollen mills in Mexico, led Mr. Sudlow to a close study of the methods whereby steam could be used in a revolving engine. In Central America he failed with his first castings, and, with the genuine enthusiasm of a pioneer, he threw up his lucrative position to return to England and complete his work. He first built a five-cylinder engine, which was exhibited at the Peel Park Manchester Exhibition in 1874. Both "Engineer" and "Engineering" favorably noticed this effort of striking novelty, but the unwieldy nature of the apparatus led to its being superseded, by a series of progressive improvements. To such perfection had Mr. Sudlow brought his air-pumps and steam-engine in 1877, that I asked him to accompany me to America, with an apparatus which is the most perfect gas-pumping arrangement that I believe has ever been produced.

It consists of two pumps capable of passing 90 cubic feet of gas per minute at atmospheric pressure, the pumps being driven by an engine which is placed on the same shaft.

Both engines and pump are of identical construction, except as to the arrangement of valves. They rest in line on a common bed-plate, and the description of one cylinder will serve for all.

The cylinder is extended upwards by a rectangular block, and is provided at its ends with closely-fitting covers having ample stuffing-boxes, suitably packed.

On removing an end cover an internal piston-cover, circular in form, comes into view. This piston-cover fits into a recess where it is packed by metallic rings like an ordinary piston. Above this cover is a rectangu-

lar flat piece of metal screwed to the rectangular block, and which, on removal, is found to close the space in which a slide moves vertically. The removal of four screws from the circular cover exposes the end of the piston, wich is arranged eccentrically to the shaft. The inner covers at either end practically complete the piston, but their main function is to equalize the wearing surface, and effectually to prevent leakage.

This is a vital point, and it is necessary to understand that one cause of serious imperfection, in most rotary engines and pumps, has been the unequal wear at the ends of eccentric pistons, which naturally travelled farther at their peripheries than at their centres. Once the inner covers are bolted to the piston this detrimental condition is obviated.

At the greatest distance from the shaft a slot is cut into the piston and into this is fitted a steel bar, packed automatically against the cylinder through a channel communicating with the pressure-side of the steam or gas.

In the vertical slot above the piston is a broad slide of equal length with piston and cylinder. It divides the whole into two chambers and rides on the eccentric piston. Its lower edge is convex and its upper surface is perforated by two ports which lead through to the pressure-side of either engine or pump.

The slide fits snugly in its socket and its weight exerts some influence to maintain it in contact with the piston. Corresponding to the upper orifices in the slide are the valve-openings for the inlet or exit, as the case may be, in the engine and pump. Immediately on the low-pressure side of the slide, midway in the length of the cylinder, is the induction-port provided in the pump with a valve to prevent recoil of gas.

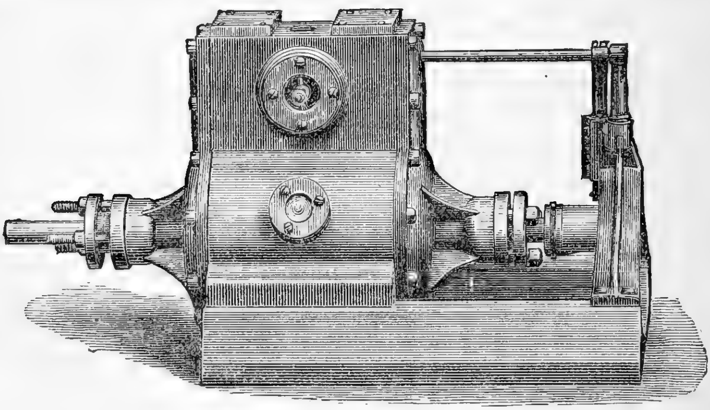


FIG. 1.

The first or lateral view appropriately indicates the compact and solid aspect of this apparatus, and indicates the manner in which the cylinder is fixed to the bed-plates, the nature and position of the outer covers with their stuffing-boxes.

The upper opening is the outlet for gas in the pump, and when used on an engine the inlet for steam. The large central flanged opening is here shown provided with an induction valve as used in the pump in order to prevent the reflux of gases towards the refrigerator. The lower aperture communicates with the water-jacket.

At the right-hand side of the drawing a bracket supports one end of a small shaft used only in the engine as a means of moving the cut-off by the action communicated to it by the spiral cam on the shaft below.

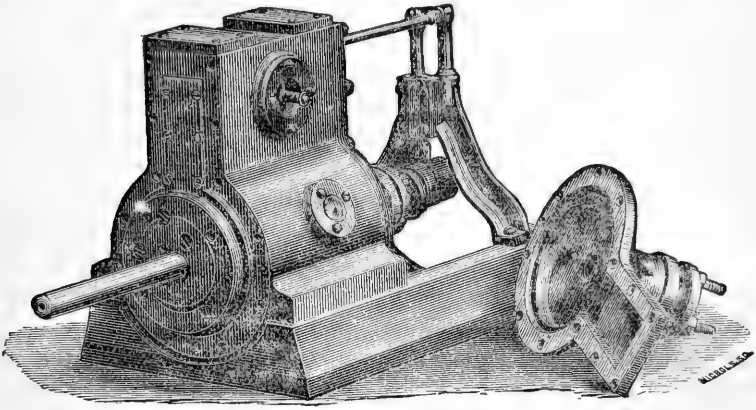


FIG. 2.

The second illustration shows one end, cover removed and exposing to view an internal cover or piston-head, which is fixed by the screws shown in the drawing to the piston within. This circular cover is seen to work in a recess formed by a projecting ridge; on the cylinder in the outer circumference of this circular piston-head is a cast-iron ring to pack and prevent leakage. Above the piston-head is a rectangular plate which closes the space occupied internally by the slide. The other parts have been referred to above, but the form of the outer cover is well shown on the right-hand side of this drawing.

The third engraving shows the internal arrangement after removal of the inner covers. The eccentric piston with the packing-bar at its periphery and the slide pressing on it above. This slide winds up and down according to the position of the eccentric piston. The slide is provided with two channel or ports communicating with two top openings, one of which is uncovered and the "mushroom" valve removed. This cover and valve are drawn on the right-hand side as shown above.

Sufficient has been said to point out very definitely the special advantages of both engine and pump of this novel design.

First. The combined engine and pump are very compact and perfectly self-contained.

Second. The position of the inlet and outlet ports at separate and dis-

tant points, so that on the heat-engine side the hot steam passes into the warmer and issues from the colder port, instead of the same channels being used alternately for the entrance and exit, as in a reciprocating engine.

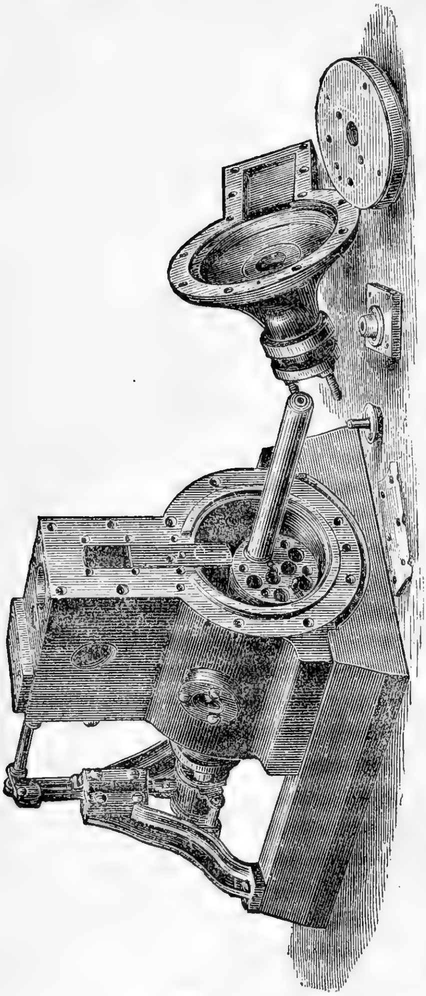


FIG. 3.

Third. The steam or gas admitted does not exert its pressure on the whole area of the piston at the initial point, but the surface increases up to the half-stroke and then diminishes, so that at the end of the stroke or point of maximum pressure, in forcing out a gas, the resisting surface is reduced. By this contrivance, the strain and friction are controlled.

Fourth. Slow valve-motion, the valves moving only once in a complete revolution.

Fifth. Permanent opening of the exhaust of the engine, so as to expel the entire contents of the cylinder, whether liquid or gaseous.

Sixth. Absolute tightness, all parts being pressure-packed.

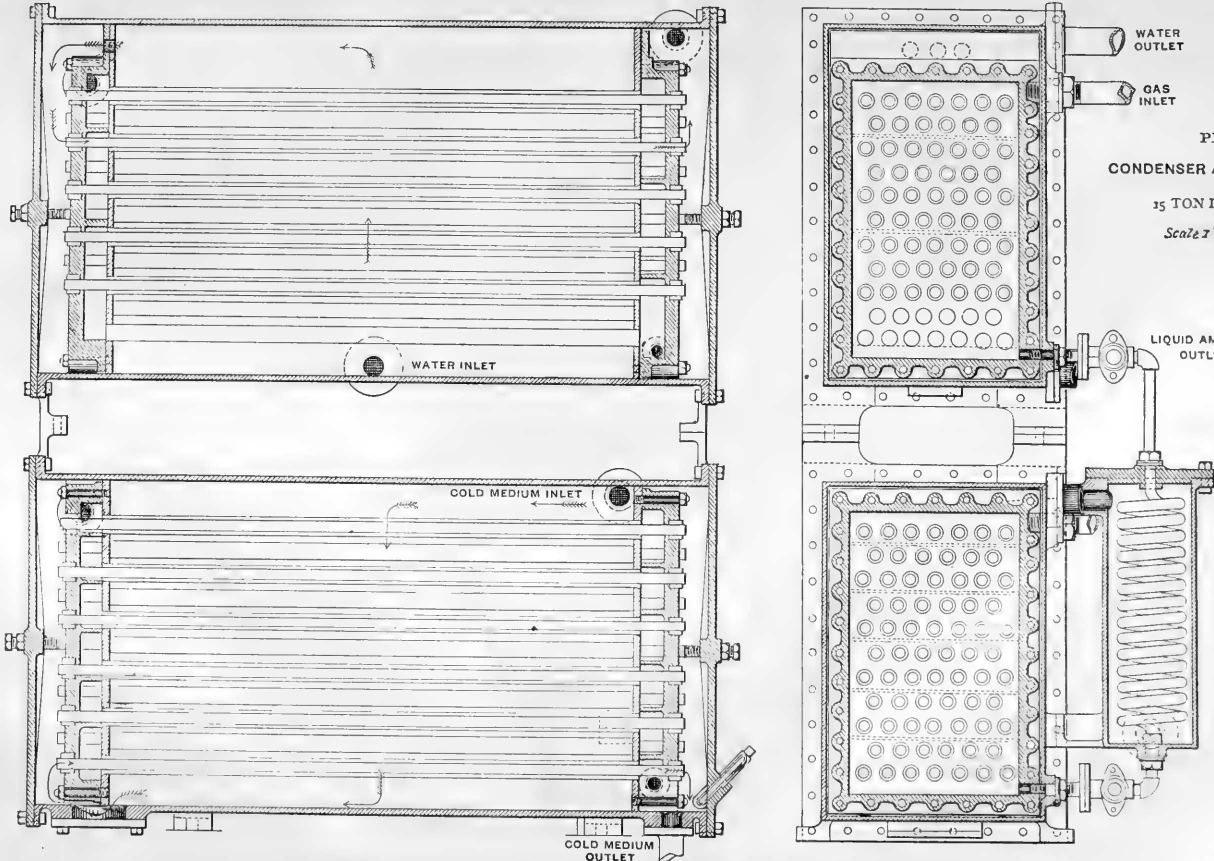
Seventh. The rotating instead of the reciprocating motion of the shaft causes a travel of but few feet per minute and admits of effectual packing.

Eighth. Placing the engine and pumps on the same shaft obviates severe strains through many joints, such as gibs, cotters, brasses and crosshead, crank-pin, crank-shaft, &c. Moreover, the pistons can be so arranged that the maximum power is exerted at the moment of maximum resistance.

Ninth. A very important feature in gas-pumps is great length of stroke, and this is admirably secured in the rotary pump. In one revolution the travel is a little over three times the diameter of the cylinder, whereas in a reciprocating pump it can only be twice the length of the crank.

R.—REFRIGERATORS AND CONDENSERS.

The annexed drawings, of tubular sections of my freezing machines, indicate the manner in which I obtain the maximum conducting surface



PLAN OF
CONDENSER AND REFRIGERATOR
FOR
15 TON ICE MACHINE.

Scale 1½ In's.=1 Foot.

with a minimum amount of the refrigerant circulating in the machine. Through a series of long tubes, fixed at their ends in tube-plates in the ordinary manner, I run a corresponding series of tubes, but of a smaller diameter and slightly longer; and the ends of the latter are likewise fixed in tube-plates, and the spaces between these tube-plates are made to form closed chambers. The interior of these chambers, at the different ends of the pipes, are connected with one another by the thin annular spaces which intervene between the inner and outer tubes. The refrigerant is caused to flow from one chamber to the other through these annular spaces between the pipes, while the liquid to be cooled passes through the small tubes and over the outer ones. In the condenser the warm gas, under compression, occupies the annular space, and a current of condensing water flows freely through the bore of the small tubes and outside the larger ones.

The ends of the outer tubes are expanded into the inner tube-plates, and the smaller inner tubes are secured at both ends in outer tube-plates by stuffing-boxes, so that the inner tubes can be withdrawn and the whole apparatus cleaned. This is an advantage possessed by no other machine.

The smaller chamber, occupied by a vertical coil leading from the condenser to the refrigerator, represents my supplementary condenser, in which the temperature is regulated so as to determine at will the pressure at which the machine is to be operated. This manifest improvement, in any form of apparatus in which gases are liquefied by compression, was suggested to me by the varying conditions observed in working freezing-machines on board ships sailing from temperate to tropical climates. The warm condensing water available at the equator led to such pressures as to interfere most materially with the economical working of the machines. By using a flow of the cooled, uncongealable liquid returning from the ice-boxes or cooling chambers, it is easy to obtain, at some cost of power, a regular temperature of 32° Fahr. or under, so as to prevent undue and dangerous pressures.

It will be noticed that so far, all freezing machines in which a liquid is volatilized, circulated, and recondensed by a pump, consist of four fundamental parts, viz, engine, pump, condenser, and refrigerator, and the improvements from time to time on Jacob Perkins's machine are improvements in detail of construction, the most important of which have rendered the machines more compact and efficient.

Every machine so far has worked with most economy, the colder the condensing water and the more perfect the arrangements for complete liquefaction, on the one side, and ready evaporation, by supply of heat, on the refrigerator side. All, except the Carré machine, which presents serious drawbacks as compared with any apparatus in which anhydrous ammonia is alternately liquefied and volatilized, have been wasteful in proportion to the inefficiency and inevitable loss of heat by the steam engine, and these considerations led me to design my

S.—THERMO-GLACIAL ENGINE.

This is based on the ascertained fact that a liquefiable gas or vapor may be cooled and liquefied by the transformation of its heat into mechanical energy. I avail myself of this by causing the gas or vapor in its passage to the refrigerator—or that portion of the apparatus where it acts upon the substance to be refrigerated—to exert its energy against a resisting body, such as the piston of an engine, whereby it parts with its heat and is liquefied to a great extent, if not entirely; in which condition it passes from the engine to the refrigerator, where it acts as the refrigerating agent. In the refrigerator it is, by the heat, abstracted from the substance to be cooled, again converted into vapor or gas, which is, by a pump or compresser (driven by the engine above named) returned to the starting point and there supplied with sufficient additional heat to overcome inertia and friction, so as to cause it again to pass on to the engine and through the same cycle of operations.

The apparatus requisite to effectuate the foregoing method of operation consists of the following leading parts:

I. A heater or boiler, in which the gas or vapor is raised to the proper degree of heat. If we suppose that the material employed be anhydrous or pure liquid ammonia—a substance which I prefer, and in practice use—then the heater or boiler is heated by suitable means to raise the ammonia to, say 125° Fahr., which will give a pressure of about 300 pounds to the square inch.

II. An engine, preferably a rotary engine, in which the piston has a continuous rotary movement on its axis in one direction. The gas from the boiler is through a suitable conduit led to the engine, where it is worked expansively, through the instrumentality of a proper cut-off, to drive the piston. In this way the heat is used up by conversion into mechanical energy, and the gas thus freed from heat assumes the liquid form more or less completely, according to the extent to which the heat has been transformed into energy. I prefer to use a double engine; that is to say, one having two cylinders. The gas enters the first or high-pressure cylinder and is there worked expansively, so as to abstract much of its heat. It thence exhausts into the second or low-pressure cylinder, where it is worked expansively still further. The expansion in each case is determined by the usual cut-off, which can be regulated by the engineer, according to conditions of use and the nature of the liquefiable gas or vapor employed, in such manner as to admit at each stroke or revolution, as far as practicable, only that amount of gas whose heat can be all, or nearly so, transformed into mechanical energy, the object being to bring the gas to a liquid condition by the time it has done its work in the second cylinder.

III. A refrigerator, into which the liquefied gas or vapor is led from the engine, and where it is brought into contact with or caused to act directly or indirectly upon the object to be cooled or frozen. The refrig-

erating agent here, by abstraction of heat from the body to be cooled, reassumes a gaseous or vaporous form.

IV. A compressor, or pump, which draws off from the refrigerator the vapor or gas as it forms, and returns it to the boiler or heater. I prefer to use for this purpose a double pump, analogous to the double engine, and driven by the engine. The vapor is returned to the heater or boiler against the pressure of the gas therein, and it is for this purpose that I prefer the double pump, in which the compression is effected by steps or successive stages, and not all at once. The vapor is compressed to a certain extent in the first cylinder; it thence passes to the second cylinder, where it is still further compressed and forced back into the boiler. The pump is provided with the usual puppet or check valve, for preventing back-pressure; said valves opening only at the concluding part of each revolution or stroke of their respective pistons.

V. Between the pumps and the boiler, heat may be rejected in a surface condenser in which water is the circulating medium, and the liquefied ammonia at the temperature of the surrounding water may then be forced by an injector or by a special force-pump into the ammonia heater.

VI. By the use of a steam-engine aiding the compression and practically lifting the ammonia directly from the refrigerator to the ammonia heater, no direct heat need be applied to the latter, and the amount equivalent to the energy developed by the steam-engine takes its place.

Subject strictly to thermodynamic law, a maximum economy can by these means be obtained for the abstraction of heat from surrounding objects.

It is evident, inasmuch as the heat abstracted from the agent to be cooled is availed of, comparatively little additional heat is required to bring the vapor or gas to the condition for imparting motion to the engine piston.

I propose to distinguish the apparatus in which this cycle of operations can be conducted by the name of "Thermo-glacial Engine."

T.—DRY COLD AIR AS A PRESERVATIVE.

We learn, from Turner's Embassy to Thibet,* that the flesh of animals is preserved frost-dried—not frozen—and it keeps without salt. He says: "I had supplies of this prepared meat during all the time I remained at Teshoo Loomboo, which had been cured in the preceding winter. It was perfectly sweet, and I was accustomed to eat heartily of it, without any further dressing, and at length grew fond of it. It had not the appearance of being raw, but resembled in color that which has been well boiled. It had been deprived of all ruddiness by the intense cold."

Frozen meat, unless losing actively in weight by evaporation owing

* 4°, London, 1806, p. 301. Quoted by Samuel Parker in his Chemical Essays. Bohn, 1841. London.

to the dryness of circumambient air, will, like frozen fish, decompose on exposure to warmth. The decomposition is activated by atmospheric impurity, and it is easy to understand how, in the mountains of Thibet, the rarefied air, of great dryness, mobility, and freedom from putrefactive germs, would satisfy the conditions for abstracting sufficient moisture, even from frozen meat, whilst effectually precluding decay. Pure dry air, either hot or cold, being an admirable desiccant, is, under suitable conditions, an excellent preservative. The charqui of South America, salted, it is true, is a product of sun-drying; and the desiccation of carcasses without decomposition, on the plains, has been a matter of common observation.

In preserving meat in England by the use of antiseptic gases, I encountered no difficulty, especially as to temperature; but in sending meats to different parts of the world, I soon learned that close packages favored mould, whereas a very mild preservative, with desiccation, would keep meat at all temperatures. Some mutton that I brought over to America with me from England in January, 1868, having been well preserved by means of carbonic oxide and sulphurous acid, arrived in New York mouldy, from having been packed in canvas and wooden boxes. The mould was scraped off and the meat proved excellent, some being eaten in Chicago as late as September of 1868, having been preserved about ten months. The meat was fresh and juicy. In Chicago and Texas the difficulties of high temperature were encountered, and in the early part of 1869 I first attempted the cooling of meat, for its after chemical preservation, by blowing air through a chamber in which bullocks and other animals were hung. I adopted two plans: one with ice in the room, the air-current being produced by a Root's blower; the other was by passing the air through a coil surrounded by frigorific mixtures. These experiments satisfied me that dry cold-air currents were indispensable to the preservation of meats in the South, and I was thus led to study the Carré ice-machines in New Orleans. Thence I returned home, by way of Washington, and devoted myself to the study of artificial refrigeration. The best machine for my purpose at that time was Harrison's ether-machine, as constructed by Messrs. Siebe & West, and I erected one, shortly after my return home, for the purpose of completing my investigations. Three concrete chambers were built with a metal roof, over which the cooled brine flowed and passed into an air-cooler composed of pipes, through which the air passed and around which the brine flowed back to the machine. As in Texas, I used a Root's blower, and established a continuous current, using the same air over and over again, so as to dry and cool the meat. I used burnt air and sulphurous acid to complete the preservation, and shipped large quantities of meat to all parts. The result of all these costly and varied experiments may be summed up under two heads:

First. All meat packed in hermetically-sealed cans, in wooden boxes, in salt and oat-hulls, like hams for the China trade, became mouldy and

rotten. Desiccation had been slight and the antiseptics had been used in moderate doses, to avoid adventitious flavor.

Secondly. Meat in canvas shipped anywhere, but most frequently to the Brazils, and on one memorable occasion, by the steamship Somersetshire, to the port of Melbourne, Australia, arrived in excellent condition. Indeed, the mutton on board the Somersetshire was served one day in each week to the passengers, and proved better than the mutton newly killed on board. It was juicy and tender.

The inference was manifest—slight but progressive desiccation at any temperature protected the meat from mould.

In 1857, that most fertile inventor and distinguished physicist, Mr. C. W. Siemens, had conceived the idea, of blowing cold air into a cellar or chamber, for the obvious purpose of preserving perishable material. He only sought provisional protection for the process of compressing air, cooling it, and then expanding it in a cylinder or engine, immersed in brine or a solution of chloride of calcium, so as to obtain low temperatures.

Shortly before the Franco-German war in 1870, I erected appliances in Paris, to show my method of meat-preservation, and I used ice and salt to dry and cool the air so as to avoid the expense of an ice-machine for the simple purposes of demonstration. The Emperor Napoleon was to have witnessed my experiments, but I returned to London, the war broke out, and some of the meat remained hung up in the open air till the first siege of Paris, when it proved most acceptable.

I have purposely entered into these details, since whatever may have been conceived by others was unknown to me, and I believe I was at least one of the first to erect an ice-machine with an adequate apparatus to utilize pure, dry, cold air for the preservation of meat. The summer of 1870 showed me that atmospheric air did no harm to the cured meats; but, on the contrary, that the more we attempted to check its circulation by enveloping the meat the more difficult was its transportation across the seas.

It is also certain that all the methods of producing cold-air currents around meat for transport were practically anticipated by me early in 1869, and the person of all others who deserves the most credit for the development of the meat-trade with England by the dry cold-air process, using ice, is Mr. T. C. Eastman, of New York. His enterprise, wealth, and trade facilities enabled him to adopt a patented process, that of Mr. Bates, which demanded much courage and capital for its development. Its success has been one of the most important commercial victories of the current decade.

Mr. Eastman writes me on the 25th of December, 1878:

"We commenced the shipment of beef from this country to England, September 29, 1875, and shipped during the balance of that year 299 cattle, 125 sheep, 25 lambs, and 20 pigs.

"In the year 1876, 17,099 cattle, 6,657 sheep, 1,935 pigs.

"In the year 1877, 38,466 cattle, 20,773 sheep.

"In the year 1878, 56,850 cattle, 45,641 sheep, 2,219 pigs.

"The shipments for the year 1878 are not complete, as we will ship about 1,500 more cattle, 1,200 sheep, and 600 pigs, before the 1st of January, 1879.

"As to our method of carrying these meats you understand perfectly. We shipped very light of dressed meat during the summer months of 1878, as the large shipments of live cattle interfered with dressed meats, which we think will be the case in the summer of 1879. We will ship for the next four months an average of about 1,800 cattle, 2,200 sheep, and 600 pigs weekly, but will reduce our shipments very much about the first of April, and ship heavily of live cattle during the warm season.

"We commenced this business in a small way on the start, and have increased from time to time till our outlay in refrigerator boxes and machinery has amounted to $175,000. I shipped the first beef that was shipped to Europe as an article of commerce. In fact, all small experimental shipments, which amounted to very little, were failures."

What Mr. Eastman has done for meat others can do with fish, and I am informed that Mr. Eugene Blackford shipped American salmon some years since, the only drawback to the business being the want of cold storage to keep the fish in good order in London.

On the 4th of May, 1870, the Baltimore and Texas Steam Transportation Company was organized, and in its prospectus it is stated that fresh beef, mutton, and game had been conveyed from London to Rio in the steamer Rio de Janeiro fitted with the Tellier machine, and after a voyage of 21 days they were found in perfect condition. During said trip, and whilst on the equator and in its vicinity, the temperature in the refrigerating-room was kept at from 32° to 33° Fahr., while outside it ranged from 105° to 107°, and the water itself stood at 80° to 90°.

On the 6th of December, 1870,* M. Ch. Tellier addressed a note to the Academy of Sciences relating that he had kept rooms at 0° C., or at most at—1° C., and had preserved beef, mutton, game (with fur, feathers, and entrails), and fish for seven and nine weeks. He said: "What I employ is a current of cold air, below 0° C., or currents of liquids between —8° C. and—10°. · · · A slight and gentle desiccation amounting to 10 per cent. of the weight of meats in six weeks is attended with preservation of the product." The abstraction of 18 or 20 per cent. of the moisture at low temperatures *in vacuo* will cure meats. In a second note addressed to the Academy of Sciences on the 27th of December, 1870, M. Tellier says that he first attempted desiccation *in vacuo* in 1867. By the aid of chloride of calcium a piece of meat was made to lose 25 per cent. of its moisture. Pasteur had recognized that from 25° to 40° C. (from 77° to 104° Fahr.) was the most favorable range of temperature for putrefaction. Thirty-two degrees Fahr., or 0° C., and 212° Fahr., or 100° C., completely prevent it. Tellier says practice accords with science. At

---

*Conservation de la Viande, &c. Par Ch. Tellier. Paris. 1871.

0° C. putrefaction-germs are inert and at 212° they are boiled. He goes on to say that *Mycodermia cervisiæ* is inert at 0°, vegetates at 7°, 8°, and 10° C., and above this temperature multiplies with enormous activity, but then other parasitic ferments appear. *Mycodermia aceti* requires a temperature from 20° to 25° C. The lactic ferment is produced from 25° to 30° C. In beer-yeast, *Mycodermia cervisiæ* or *vini* vegetates at 7° or 8°, whereas temperatures of 15° or 18° are required in raisin-yeast. Rotifera remain inert for an indefinite period if dried; in water, they move, live, and have an active existence. Yeast dried and pressed is inert; moistened, it forthwith manifests activity. Augustus Smith found that below 10° C. blood does not readily decompose; above this temperature, changes occur which are very rapid at 22° C. At 16° C., the putrefaction of half a litre of blood will yield 100 cubic centimetres of carbonic acid in 24 hours. At 22° C., the same quantity, in the same time, will yield 400 cubic centimetres, viz, four times more by a rise of only 6° C.

M. Poggiale, the distinguished inspector-general of military pharmacy in Paris, presented a report on the 31st of March, 1874, to the Academy of Medicine of Paris, and which report was made to the "Conseil de Salubrité de la Seine."* Poggiale remarked that since 1850 he had had frequent occasion to study for the war department the various processes of meat-preservation, such as salting, drying, the use of sulphurous acid, carbolic acid, and creosote; coatings of gelatine, sugar, or glycerine; vacuum, artificial atmospheres, hydrochloric acid and sodium bisulphite, meat-extract, cooking in closed vessels, &c. None but the method Appert (the now common method of cooking in hermetically-sealed tinned cans) solved the problem. He then goes on to say that M. Tellier believes he has discovered the right process. To obtain this result it suffices to maintain at 0° C. or at —1° C. the temperature of the chamber in which the meat is placed. To be precise, I shall quote literally: "Pour produire le froid il n'emploie pas la glace, qui donne de l'humidité et qui n'abbaisse pas suffisamment ni régulièrement la température de la viande. Il prefère un courant d'air froid ou plutôt des courants liquides à —8°. ou —10°, qui, congelant l'humidité de l'atmosphére, la dessèchent et en abaissent la température. L'operation consiste donc à établir des magasins frigorifiques dont la température sort de 0° à —1°."

He goes on to describe Tellier's methylic ether process of producing artificial cold, and his isolated room with powdered coal between the walls. In this chamber there were four tanks with a wooden pipe for the circulation of cooled calcic chloride solution. He adds: "Pour que l'action frigorifique soit uniforme dans toutes les parties de la chambre, ou y a établi un ventilateur qui prend l'air à l'une de ses extrémités, le fait passer dans le conduit contenant les bassins froids et le force à sortir par le côté opposé de cette même chambre. L'air est donc constamment renouvelé, bien que ce soit toujours le même air."

* Importation en France des Viandes fraiches conservées par le froid. Paris: Imprimerie de J. Claye, 1874.

M. Poggiale observed two partridges which had been placed in the chamber on the 1st of February, had been taken out on the 5th of March in excellent state of preservation, and weighing 786 grammes. Half a sheep, kept at 0° C. for 37 days, presented all the characters of fresh meat; the weight, which had been 8.8 kilos, had fallen to 7.5 kilos; the loss was, therefore, about 12 per cent. in 37 days. He concludes his report by saying that M. Tellier proposed to convey meat from Montevideo, in 25 or 30 days, to Paris, by Rouen, and there placed in cold store for sale. He considered M. Tellier's experiments as of great interest as a matter of public hygiene, and that he deserved to be encouraged.

So important was this question considered that Professor Bouley, member of the French Institute, and Inspector-general of Veterinary Schools in France, was called upon to make two reports: the first on the 28th of September, 1874, to the "Comité Consultatif d'Hygiène publique de la France," and the second on the 5th of October, 1874, to the French Academy of Sciences. These reports bear out M. Poggiale's statement, but contain a few facts and observations which merit record here. Having described the methylic-ether machine and the method of cooling the rooms, he points out, according to Tellier's experiments, that meats which lose 10 per cent. of weight the first 30 days, viz, 3.33 grammes per kilogram per day, only waste 5 per cent. the second 30 days, or 1.65 grammes per kilogram per day. Beyond this, the drying continues very slowly, and at the end of eight months the interior of the meat is still moist. The duration of the preservative influence of cold may be regarded as indefinite; but, whilst meats really improve, during the first 40 or 45 days, they deteriorate somewhat, for the purposes of sale, beyond that time; they become too tender, and there is a fatty flavor, "une sensation gustative qui rappelle l'idée d'une matière grasse." M. Pasteur was invited by Professor Bouley to his home to taste some meat, and he inquired if the quarter of beef could be preserved as well as a quarter of mutton, and whether some change would not occur near the bone. A hind quarter of beef weighing 140 pounds had a thermometer plunged into its most fleshy portion at a depth of 18 centim. (about six inches), which took three days to fall from 36°.6 C. to 0° C. But this did not in the least interfere with its preservation, because the air is purified in circulation and the low temperature deprives the germs of activity.

The experiment at M. Tellier's place at Auteuil has proved that the temperature may vary from —2° to 3° C., viz, from 28°.4 to 37°.4 Fahr. During the hot month of June, 1874, the temperature rose in the cold room to 8° C. or 46°.4 Fahr., owing to the ice-machine having to be stopped for 36 hours; but a haunch of beef, weighing 140 pounds which was in the room during these oscillations for 51 days, was admirably preserved, and all who ate of it recognized that it was better than meat killed 24 or 48 hours before being cooked.

The experiments which the reporters had to refer to were conducted from the 29th of November, 1873, to the 7th of July, 1874.

Professor Bouley remarks, in his report to the Academy of Sciences, that "the knowledge of the preservative action of cold on organic bodies is, without doubt, as old as humanity itself, and every day one has recourse to this preservative influence for the preservation of alimentary substances. M. Tellier cannot, therefore, pretend to this invention. But that which is new in this process, which he has brought before the Academy, and which constitutes a real invention, is the idea of creating a dry and cold atmosphere, in which organic matters may be preserved permanently; atmosphere which is circulating without ceasing from the cold room to the refrigerating apparatus and back to the room in order to maintain the required temperature and abstract the moisture." "Grâce à ce circulus, on bénéficie de l'abaissement de température une fois acquis, et l'air revient à la chambre froide, desséché et purifié." This, he says, is the ingenious process of preservation of organic matters, and particularly of meats, which M. Tellier has communicated to the Academy. "Your commission has recognized its efficacy under the conditions under which it has been applied. But they must practise every reserve as to the industrial application that may be made of it. Experience alone can determine its economic value."

That M. Tellier had only then developed his practical methods may be gleaned from his English patent dated the 11th of August, 1874, No. 2,770. He says: "My process has for its object a slow desiccation combined with the action of cold exerted at temperatures approaching to 32° Fahr., but without congelation for organic substances under 32° Fahr., with congelation for amorphous substances, such as butter. Such desiccation requires to be graduated according to the nature of the articles to be preserved; and particularly with regard to meat, it must be slight when it is required to preserve the meat in the ordinary condition of butcher's meat, in which case a desiccation equivalent to a loss in weight of one-quarter to one-third per cent. per day is all that is necessary." He moreover says that the air may be dried by passing through the refrigerator of any suitable machine, and the desiccating property may be increased by causing the air to pass over dry chloride of calcium or other agent absorbing moisture readily.

M. Tellier had evidently been developing his idea over a period of four or five years, but he was neither alone in these efforts nor was he unanticipated.

To those who have known the nature and extent of my experiments since 1865, and especially from the autumn of 1869 to June, 1870, with the many efforts made in 1871, 1872, and 1873 to carry out, on a large scale, the transport of meats in dry cold air, I need not address a word. I saw Professor Low's ship, with a carbonic-acid refrigerating-machine on board, in 1869. Had he been fortunate enough to use more manageable chemicals he might have succeeded; but, like Mr. Mort, of Sidney, Mr. Harrison, of Victoria, and many others, he proposed to freeze meat, and that system I then, and ever after, condemned. In 1873, after hav-

ing made various improvements in freezing-machines, I published a pamphlet, in which I said:

"Frozen meat has kept for ages, and during the Russian or North American winters the people are compelled to put up with it. Freezing is, however, prejudicial to the meat, and commercially impracticable, since it necessitates the construction not only of ordinary ice-houses, but of *freezing-chambers* at the ports of shipment and landing, and there are innumerable impediments in the way of getting the frozen produce delivered untainted to the consumer. Experimentally the process is simple and quite successful, but not as a means of supplying the nation's food.

"PRESENT PROPOSAL.—Since my return from America my labors have been constant, and my chief difficulty has arisen from the imperfect construction of all the machines employed in refrigeration. Not only did I find that the method of promptly cooling a large body of meat—say, two or three hundred bullocks at a time—was unknown, but the machines at our disposal could not be depended on. This difficulty I have now completely overcome, and in designing a steamer provided with a compound tubular freezing-machine, I have held in view the following points:

"1. The preservation of meat for seven or eight days, and even longer, insured by cooling the carcasses down to 40° or 45° Fahr. immediately after slaughter.

"2. Meat moulds and deteriorates in a *still* and *damp* atmosphere, but if the air be circulated and kept dry the meat retains a firm and florid aspect, and the currents of dry cold air may be so regulated as to keep the meat for an indefinite time.

"3. Not only for the transportation of fresh meat, but likewise for the transportation of fish, fruit, vegetables, eggs, cheese, &c., steamers, the holds of which can be kept by an economical system at 40° or 45° Fahr., or even as high as 50° Fahr., will command a large trade.

"The machine which I have perfected especially during the past two years enables us, by the use of ether, to have a body of liquid in a tank at the upper part of a ship's hold, corresponding to any number of pounds or tons of ice required to maintain a steady temperature in the hold. Brewers have taught us by prolonged experience that it may be economical to cool down to 40° or 45° Fahr., whereas freezing or the production of ice would be most costly and wasteful. With a compound tubular refrigerating-machine the temperature required is maintained, and it presents the immense advantage of enabling us to *cool*, *dry*, and *purify* the air that is made to circulate in the hold.

"COOLING THE AIR.—A perforated tube of adequate dimensions runs along the bottom of the hold and communicates with a fan or air-pump. From this fan or pump a tube delivers the air into the tubes passing through the cold liquid in the refrigerator. When the fan is set in motion the air is passed round and round continuously, so as to keep the meat dry and fresh.

"DRYING THE AIR.—The liquid in the tank surrounding the tubes through which the air is blown can be readily kept at a point a little above freezing, and the tubes are so placed on an incline that the moisture condensed from the circulating air trickles back and is drawn off at will. Condensation by cold surfaces is the cheapest and best method of drying air. The evaporation from the hot meat helps to abstract the animal heat, and when the meat is cold the continuous draughts of cold dry air are most beneficial.

"PURIFYING THE AIR.—One effect of the constant circulation of the air of the ship's hold through damp cold tubes is that it gets completely purified, and germs of decay and of mould are arrested. The atmosphere is sweet and pure, as well as cold, and this is one of the most desirable results attained by the plan now devised."

U.—DOES ICE DRY AIR?

I then believed, as I do now, that great economies and certainty would attend the use of antiseptics in conjunction with moderately cold air-currents for long voyages, and, since I have been in America a second time, I perceive that the crude ice method might have been attended with less loss and difficulty, had the persons engaged in the business acted under competent scientific advisers. So uncertain are they of the principles under which they work that some believe ice dries, and others that it wets air, whereas the truth is that ice condenses moisture from damp air warmer than itself, but will give up moisture to dry air at any temperature. Evaporation goes on from a surface of ice or snow at 32° Fahr. In the open air, and in a perfectly still night, the moisture amounts to nearly one ounce for every square metre exposed per hour. At 0° Fahr. nearly a quarter of an ounce of watery vapor rises per square metre per hour, and at 32° below 0° Fahr. more than two pounds of invisible vapor ascend into the air from every acre of surface. Thirteen to fourteen hundred pounds of watery vapor pass into the atmosphere for every square mile of snow or ice.

V.—PROPOSED IMPROVEMENT IN FREEZING FISH.

It is to be regretted that immense sums are invested in carrying out crude methods in the arts, and the introduction of rational and economical processes are then resisted by those who like to leave well alone. This would indicate the advantages to be derived by a careful exposition of the state of knowledge, in this case of the art of fish preservation, and, having laid down the principles involved in all known processes, a solid basis for further improvement might be established. Moreover, trials of new devices, under carefully-noted conditions, without involving very large outlay, might speedily enlarge the area of trade to the fisheries of this or any other country. It is of course difficult, for a person engaged in a large business, to change any system fairly meeting his requirements;

but in the case of the beef-trade to-day an average of 80 tons of ice per 100 tons of meat has to be carried, where a machine, occupying a ten-ton measured space, would insure better results, and guarantee the shipper against the consequences of delays at sea, from broken shafts or other causes.

Again, in the fish business the practice of freezing fish hard, and stacking them like cords of wood, may turn out to be an indispensable method for certain purposes; but the ice and salt process which I saw in 1868 in this country continues to-day, whereas it is easy to demonstrate that the art of artificial freezing should not amount to 25 per cent. of the cost of using ice at $3 to $4 per ton, and salt at best market prices, with all the labor of breaking and mixing.

Enterprising business men may justly state that up to this time promises have been scarcely fulfilled by the inventors of ice-machines, and, that the bold assertions in illustrated pamphlets, issued by persons interested in the sale of machines, have been hypothetical, often positively untrue, and no means were afforded to enable, even competent engineers, to determine on the probable issue of any costly trials. With this position of matters fairly in view, the laws and data controlling the practical production of artificial cold have been stated as fully as possible in a memoir of necessarily limited extent; and whilst it is not claimed that the subject has been in any sense exhausted, the intention has been of stating nothing but the truth, and of completing the task hereafter.

It is not, therefore, too much to hope that the more enlightened fish-culturists, who may have a knowledge of physics and chemistry to test and extend the information given, will contribute, by their influence and encouragement, to favor the development of rational and economical means, for the accomplishment of the various objects herein briefly unfolded.

W.—PRESERVATION OF BAIT AND FISH.

The proper storage and preservation of sound bait is one, if not the most important, part of a fisherman's business. Mr. Brown Goode has stated the problems to be solved on this question as follows:

1. To provide means by which a Grand Bank cod-schooner can carry 100 barrels of bait, in a compact mass, and in such a state of congelation that it can be used for eight or ten weeks.

2. To provide means for the refrigeration and preservation, for six months or more, of a quantity of bait amounting to at least 100,000 or 150,000 barrels.

Prof. Goode, moreover, informs me that it is difficult to estimate the total amount of bait consumed by the Gloucester fleet. Large quantities are salted for use in the mackerel, cod, and halibut fishery. About 35,000 barrels of "round fish" are cut up and salted for this purpose.

The George's Bank cod-fleet consume annually, something like 80,000

barrels of iced bait, chiefly menhaden in summer and herring in the colder weather. The herring are brought from Nova Scotia and Newfoundland, where they are bought frozen at the rate of 30 cents to $1 per hundred. Probably thirty voyages are made from Gloucester each winter for the purpose of getting these fish. Mr. Goode has not at hand an estimate of the quantity brought in each cargo, but it cannot well be less than 100,000 herring. The quantity thus brought in amounts to between three and four millions of herring, for which at least $15,000 are paid. Canada alone, exclusive of Newfoundland, sent in 1876 to the United States 4,361,000 pounds of herring (fresh), valued at $53,989. Besides the fish brought in the winter, a large quantity of herring are bought on the coasts of Newfoundland by the Grand Bank fleet, of which Gloucester has nearly 100 vessels. These vessels require for a season's fishing something like 100 barrels each of fresh bait. This they buy at the rate of about $2 a barrel, or somewhat more when they take them in frozen for the first spring trip. The necessity of going into port for bait uses up certainly half of the time of their four months' absence, besides which each vessel pays out from $200 to $500 for bait.

Mr. Goode estimates that Gloucester pays something like $40,000 annually for 20,000 to 25,000 barrels of herring. These herring and other fish, like the alewives, closely resembling them, occur in immense schools on the Atlantic coast during cold weather. The whole demand of Gloucester would doubtless be supplied by 120,000 to 200,000 barrels of fish, or perhaps 25,000,000 to 50,000,000 fish, frozen in such a manner as always to be available for use as bait. These fish, Mr. Goode says, if packed solid would occupy a space, approximately of 30,000 to 50,000 cubic feet. If proved good for bait, from 50 cents to $1 would readily be obtained per barrel.

The nature and extent of the bait-preserving question may likewise be inferred from the following note by Mr. J. K. Smidth.* In his paper on the Fisheries among the ancient Greeks and Romans, he states, after Oppian, that the "lycostome" (a sort of herring) were the best bait for catching the "sargus." As soon as a certain quantity has been thrown into the water they came in large swarms to eat it, and the fishermen then seized the opportunity to enclose them in their nets, and thus frequently caught large numbers. This use of bait, Mr. Smidth remarks, "in net-fishing, reminds us of the sardine-fisheries on the coast of Brittany, as carried on in our time. But here the roe of the codfish is used as a bait for the sardines. To give an idea of the enormous quantity of roe used for sardine-fishing, he mentions that 30,000 kegs of roe are exported annually from Norway to France. Each of these kegs contains about 140 kilograms, making a total of about 4,500,000 kilograms, or about 9,000,000 pounds, valued at about 3,000,000 francs. Several owners of large fisheries have assured me that the buying of this roe deprives them of half the profits of their sardine-fisheries."

* United States Commissioner of Fish and Fisheries Report, Part III, 1876, p. 7.

Coupled with Mr. Goode's statement that half the time available for fishing is consumed by the Gloucester fishermen's excursions after bait, Mr. Smidth's last remark is of great interest, as showing how vital the question of bait-preservation is to the fisheries.

Two processes are in vogue: the one which may be termed rough salting, and the other more careful handling and thorough cleaning of the fish, washing out blood and dirt, with a view to a milder salting. Salt bait is not so good as fresh bait, and there is a difference of opinion as to the relative value of whole and cleaned, or split salted fish. Since the soundness of bait thus used depends mainly on the condition of the fish when first salted, it may be desirable, even where salting is continued, to have means for the prompt cooling and drying of the fresh fish, and their more deliberate packing in barrels, as at present practised.

This seemed to have the preference, and the difficulties in its use depend (1) on the limited time it can be kept frozen and secured in a fishing-schooner; (2) on the time and distance required to secure it—*a priori*, it is not easy to understand how this form of bait can have any advantage over partially desiccated bait, and on carefully considering all I have learned from Professor Baird, Mr. Milner, and Mr. Brown Goode, it is my opinion that the best method of curing bait will be by drying at low temperatures.

A paper was read some years ago at the Society of Arts in London by Mr. Buchanan, on the preservation of vegetables by cold-air currents, and in justice to this gentleman I must say that the specimens prepared of cabbage, Brussels sprouts, onions, &c., were all that could be desired. This bore out my views as to the preservation of meats, and although absolute desiccation was essential for the prolonged packing of vegetable matter, animal produce may be made to preserve all its purity and delicate flavor by prompt and partial drying at lower temperatures, and effected in shorter time than by Mr. Buchanan's process. He placed his vegetables on trays, or an endless band, and maintained active currents of air in a confined box at ordinary temperatures, removing the moisture by chloride of calcium. This moisture could, of course, be better and more economically abstracted by metal surfaces lowered below 32° Fahr., and the dry cold air would always be preferable to temperatures varying, say, from 50° to 70°, and over. It is true that when relying on simple movement of the atmosphere the temperature may be varied at different stages of the process, and whereas it might be wise to dry slowly when the whole of the moisture in the vegetables, combined with high temperature, might lead to decay, so soon as a large percentage of the water had been removed, a higher temperature, even up to 100° Fahr., might be advantageously used to expedite the process. All aromatic substances retain their natural and unaltered characters only if dried at the lower available temperatures. It is with great confidence that I propose an extended trial of cold-dried bait.

Any quantity can be profitably and inexpensively cured by this pro-

cess. Protracted preservation on land or at sea demands only moderate care to keep the bait dry. The method of packing can be such as to economize both room and cost, as compared with barrels. The fish used as bait, if properly handled, would retain form, color, and flavor. No extraneous material requires to be used in the preservation but what can readily be had at the fishing centres. The appliances necessary for this process are—

First. Cold storage to take in cargoes of fresh bait in bulk.

Second. Vacuum cylinders for promptly drying the cooled bait.

Third. Suitable canvas and facilities for packing in bales of convenient size.

Fourth. On each boat a convenient receptacle or cabin, through which air is made to pass continually at external temperatures by an automatic process; or if a closed and dry chamber is more easily secured, a drying-box containing a small quantity of chloride of magnesium or crude chloride of calcium may be employed without any through current of air. Common salt may, in the absence of the chlorides, sufficiently dry the chamber to prevent mould.

The cold-storage system I have described elsewhere, and I need only dilate on vacuum process of drying. The good to be derived from this is that slower drying is almost sure to be attended with some change in the flavor from the action of the air on the fish. A Sudlow air-pump such as I use for pumping ammonia gas, will create and maintain a vacuum in wrought-iron cylinders with adjustable covers, so that in two or three days from 15 to 25 per cent. of moisture is abstracted from the bait. The less it is dried the better, perhaps, except for keeping-properties, and here is the only question demanding experiment. I would propose a supply in suitable boxes of bait dried to the extent of 15, 20, and 25 per cent., and if the abstraction of the smaller amount of moisture were not inconsistent with preservation, in bales enclosed in a drying-chamber, it would be useless expense and an actual disadvantage to attempt further desiccation.

The *barrel* system of packing would favor mould, and thus affect the flavor and freshness of the bait; but coarse canvas, admitting of the escape of moisture, however slight this may be, will constitute a solid and sufficient covering for the bait. My experience as to packing the carcasses of mutton and quarters of meat, to hang them up in any convenient place where they can be kept dry on shipboard, indicates that with the most ordinary precautions the bait can thus be stowed away. Should an accident lead to their getting immersed in sea-water, the bales may be hung up like sails to dry in the rigging, and will keep sound and sweet at any temperature.

The *chamber* or *receptacle* on the schooner should be under lock and key and under the skipper's control. The only condition required is dryness, but if the regulations, as to the maintenance of purity and cleanliness in the bait-houses, are not preserved, a sea may be shipped,

swamping the bait-house, and great trouble thus caused by damaged bait. I do not believe cold-dried bait will demand any more care than salt or frozen bait, but the chances of its prompt, beneficial and economical introduction depend on care and foresight in the first trials, and until the fishermen become familiar with its use. The nearest approach to live bait will be the carefully-preserved dry fish, which, on being submerged, may promptly regain plumpness, should drying have to be continued so long as to shrink them perceptibly.

X.—PRESERVATION OF SALMON, COD, HALIBUT, &c.

Appert's method of cooking in hermetically-sealed tin cans has proved a great boon to fisheries. The salmon-canneries on the Columbia and Sacramento Rivers, not to speak of the sardine-trade in France and elsewhere, the canned oysters of Baltimore, canned lobsters, &c., indicate how indispensable a cheap mode of fish-preservation is found in supplying the people's food. This subject deserves attention, and it would be well to know why canned fish, like canned meats and fruits, tend in the long run to nauseate, or, at all events, not to be eaten with the same relish as on first trials. I believe it will be an immense advantage if the cost and inconveniences of tinning can be set aside; and on sanitary grounds this may be very desirable. The contents of cans, containing cooked fish of all sorts, should be subjected to analysis, making a selection of different dates, so as to ascertain what the influence may be of protracted preservation in contact with metals. In the Chemical News of July 5, 1878, page 5, Mr. Albert E. Menke, of the chemical laboratory, King's College, London, writes as follows: "In opening a tin can of pine-apples I found that at the place where the tin had been soldered corrosion had taken place, which induced me to test for tin, having found indications of it, and made a quantitative analysis with the following results: I first poured the syrup off, and squeezed the juice from the fruit, then oxidized with chlorate of potash and hydrochloric acid, boiled, and then reduced the tin to the stannous state with sulphate of soda; sulphuretted hydrogen was then passed through the liquid, the tin sulphide was then filtered off, dissolved in strong hydrochloric acid, largely diluted and titrated with potassium permanganate. 0.151335 gramme of tin was found in a tin of pine-apple which weighed $1\frac{3}{4}$ pounds. I next tried lobster and apples, and found in the lobster 0.010089 gramme, and in the apples, 0.00672 gramme of tin, showing that the pine-apple was the worst, which would support the theory that it was due to corrosion."

Salting, *smoking*, and *drying* by the sun or at ordinary temperatures, are the commonest methods of fish-preservation, which are attended with great difficulties in the summer season, when unexpectedly large catches demand more hands, more time and conveniences than have been usually provided. Thus a successful haul is sometimes a cause of loss rather

than profit. Cold houses, for the temporary preservation of fish, are, therefore, even for these purposes, invaluable.

It is not my object to dilate on those used for the process of *freezing*, as adopted by some of the more enterprising dealers in fish. If, as I have before said, it be found best to freeze fish under certain circumstances, the most economical plan admits of very ready description.

Mr. Frank Buckland informed me some years since that he had received in London, from Glasgow, a mass of fish frozen in a block of ice; that they looked well, but could not be separated for the trade without thawing the ice. This experiment, often repeated, indicates how effectually not only one but many fish may be frozen *en masse*. It may be incidentally remarked that certain kinds of hardy fresh-water fish may be frozen alive in a block of ice, and kept there for a time not yet well defined, but extending, at all events, over many days or weeks, and on thawing the ice the fish prove to have been unharmed. What temperature they will withstand is not known, and, in relation to fish-culture, this is another field for inquiry of the highest interest. It is just possible that some fish may be transported frozen to stock rivers or seas more easily than they can be carried in a water-tank, and whether a sole or turbot will resist such usage I cannot say; the experiments have yet to be made; and all we know is that some fish, like pike, may survive the process. It would not be difficult to try the experiment, inasmuch as a flat metal can containing the fish could be very rapidly frozen by a surrounding solution of glycerine and water from a freezing-machine, and, by selecting the proper cryogen, a temperature not much below 32° Fahr. might be readily maintained in a tub, containing the said metal can, on its passage across the Atlantic. The information at my disposal is so scanty that, apart from the fact that fish have survived freezing in a solid block of ice, I know nothing. It occurs to me, however, that in all probability the temperature of 32° Fahr. is low enough for most fishes, and the obvious use of common salt and ice might be attended by too low a temperature to insure success. Many failures may be anticipated; but without these, good work was rarely performed.

The present practice of freezing each individual fish solid and then keeping a quantity on hand from seasons of plenty to those of scarcity, is, of course, more feasible because less costly by the use of an ice-machine than by ice and salt. The uncongealable liquid would take the place of the brine, and very little, if any, alteration in plant, beyond the addition of a machine, would probably be required. The sooner the fish are frozen after being caught the better, and they must not be allowed to thaw until the time for cooking them. Frozen fish are packed in fine sawdust and closely boxed to be sent two or three hundred miles, thawing out slowly in transit; they are then dropped in water to complete the thawing, and are ready to cook.

Professor Goode informs me that "the total amount of iced halibut brought annually to the port of Gloucester is not far from 10,000,000

pounds. More than two-thirds of this, say 7,500,000 pounds, is brought from the Banks, or the coast of Nova Scotia, in vessels fitted out for the halibut-trade. Of these, there are about thirty which pursue the fishing part of the year, at least. The Bank halibut are brought in cargoes of from 15,000 to 80,000 pounds. The average weight of halibut is not far from 50 pounds, though individuals of 150 pounds are by no means uncommon. The length of a trip to the Banks for halibut is usually about three weeks, about half the time being consumed in making the passage to and fro.

"The remainder of the supply, which is perhaps something more than 2,000,000 pounds, is brought in small lots of 2,000 or 3,000 pounds by the vessels which fish for cod on the George's Banks. There are over one hundred of these vessels, which make one or two trips per month each throughout the year.

"The halibut as soon as they are caught are packed in broken ice in the hold of the vessel, which is divided up for that purpose into bins about eight feet each in dimensions.

"When they are brought on board the vessel their temperature is probably not much greater than that of the water in which they were caught, say 38° to 40°, the bottom temperature being about 33° to 34° Fahr. They are very cold when landed on the wharf at Gloucester, usually colder than 45° or 48°.

"They are immediately packed for shipment in pine boxes holding about 450 pounds; their abdominal cavities being filled with chopped ice, which is also plentifully bestowed in the crevices between their bodies.

"The weekly receipts of halibut probably range from 100,000 to 700,000 pounds per week, and sometimes the quantity is greater."

A halibut-schooner carries from 18 to 50 tons of ice on a trip; the largest quantity in summer. The amount annually consumed by the fleet does not fall much below 8,000 tons. This includes a certain amount allowed proportionally to the George's fleet.

Prof. Goode says the problem here to solve is how "to provide for the refrigeration and preservation on shore for one or two weeks of 10,000 or 15,000 halibut, weighing perhaps 50 or 60 pounds each."

It is well in all industries to depart as little as possible at first from established customs. Pending adequate experiments, it is quite certain that the boxed halibut must be placed in a room at 30° Fahr., in which the ice used at sea would not melt. The lids might be removed, to be replaced when the fish have to be shipped; but I see a positive advantage in resorting to the least possible disturbance, or handling of the fish, whilst insuring their preservation for so limited a time. Moisture is as great a factor, if not a greater, than heat in developing putrefaction; and a current of dry air at low temperature would check all mould or other parasitic vegetation; and a little fresh ice when the boxes are shipped would meet the very simple requirement of equalizing supply and demand by a preservation of one or two weeks.

There is a manifest difficulty in the way of resorting to any but the least costly process of transporting the fresh fish from the boat where it must be iced to the consumers. Any plan of preservation available for greater delays in transit, such as the supply of European markets might, in time, supersede the more precarious process hitherto in use.

It might be desirable to have cold chambers on the fishing-schooners, so that the ice should not melt in the boxes; and in time suitable refrigerators may be introduced amongst the fishermen. The prompt and practical remedy, however, lies in disturbing as little as possible the course of the trade; and so far as my experiments with fish have extended I have not found any preservative so good as ice; its only disadvantage is the melting, and to prolong its effects with a minimum deterioration of the fish is simply to keep the whole at a temperature which will fail to freeze the fish but will preserve the ice and insure dryness. The more complete the desiccation, so long as ice is around the fish, the more certain the result.

It is not improbable that this combination of using ice and artificial refrigeration may settle the problem of shipping fish to the English markets, and it is my intention to further by all means in my power the establishment of cold storage in England for the reception of all kinds of American produce, including fish. The obstacles I have met so far in this have resulted from the difficulties in inducing the agents in England to anticipate any preparations without coöperation by American exporters, and in America such men as Mr. Eastman in the beef business have little confidence in investing capital except under their own eyes, but when they see, there appears to be no limit to their enterprise.

With the lead taken in fish-culture in America, it is to be hoped this matter of making provision at the European centres of consumption for the reception and preservation of fish may meet with fewer obstacles than I have encountered in ten years with all the suggestions, admitted to be sound, in relation to the meat-trade.

Y.—DRY COLD WITHOUT ICE.

This plan so successful with the meat can be made to succeed with fish, but I hesitate to develop a complete plan on the slender knowledge I have of the possibilities in the fish-trade.

One thing is certain, viz, that drying without salt or smoke, so as to keep a split fish in the most perfect condition for some weeks, to be restored by a few hours' immersion in pure cold water, is practicable. Water can be abstracted and replaced from and into the most delicate animal tissues without the slightest deterioration or the development of adventitious flavor. This is undoubtedly the process which will supersede canning to a large extent on the Columbia and Sacramento Rivers, and it were well if, with the progress of fish-culture, these methods were made the subject of experiment and demonstration, so as to encourage capitalists to ship fish as nearly like grain in bulk, without incurring

needless outlay, and spending money either to destroy the texture or the flavor of the materials preserved.

Where ice is at hand and ice-machines cannot be obtained, the use of a very simple refrigerator maintained just below 32° will keep the air dry, whilst its rapid circulation insures the more or less active shrinking and preservation of the fish. It is most economical almost anywhere to use an artificial process of producing the cold, for a building 70 feet long by 40 feet wide, divided into two or more floors, can be kept in a suitable state by a machine capable of producing only a couple of tons of ice daily, at a cost not exceeding, under proper conditions, $100 per month.

Z.—THE GLACIARIUM.

I cannot refrain here from pointing out the great importance in such cities as New York, Boston, Philadelphia, Baltimore, New Orleans, San Francisco, and a host of minor ones—indeed, all above 25,000 inhabitants—of establishing places where refrigerating-machines may serve to produce pure and cheap ice, preserve provisions, favor such industries as fishing and the inland transport of food, and provide, especially in the South, the means of getting pure water from the sea instead of rain-water, or ministering to the comfort of the inhabitants in hot weather by providing cool chambers at a temperature between 60° and 70° for purposes of recreation and athletic exercise. When I first constructed an ice skating-floor, it was simply with a view to encourage people in the idea that if engineers had been baffled by the difficulties of the subject, they were not insurmountable; but from the success in maintaining such sheets of ice during the hottest weather in summer, and even in an iron boat—the floating swimming-bath on the river Thames—led to a clear perception of the field there was in the future for the processes, perhaps too tardily developed. Ice-men only think of making ice, and in England the scanty use of ice in the largest cities retards the introduction of one of the most powerful aids to the promotion of heath, comfort, and economy, viz, the artificial production of cheap cold.

To recapitulate, a glaciarum includes—

First. The manufacture of pure, transparent crystal ice, containing as low as one-tenth of one per cent. of matter in solution or suspension, and hence absolutely free of all known impurities calculated to render water or ice unwholesome.

Second. The manufacture of ice in bottles—the carafes frappées of the Parisian cafés.

Third. Cold stores for meats, preserved provisions, fish, game, fruits, vegetables, &c.

Fourth. Storerooms for the protection of all articles attacked by insects during the summer, and which insects are killed, or arrested in their process of reproduction and development, by temperatures approaching the freezing-point of water. Thus, furs, feathers, woollen and

other goods may be preserved in a state of perfect purity and freshness, free from moths, &c.

The destruction of fever-germs, such as the poison of yellow fever, at or below 32° Fahr., indicates that articles of wearing-apparel and furniture placed in such chambers, with absolutely dry cold air, 20° to 30° below the freezing-point of water, would constitute an invaluable adjunct to the means employed by sanitary authorities for effectual disinfection. The air blown, over metal surfaces and through antiseptic sprays, can be made to operate on every part of infected fabrics, without damage, however delicate they may be.

Fifth. The wholesale manufacture of ice-creams, ice-puddings, &c., constituting in some large cities a most profitable industry.

Sixth. The maintenance, especially during the winter season, of sheets of ice for skating and curling purposes. The pastime of skating may be indulged under cover in an atmosphere warmed suitably to avert colds and chills; and the ice being frozen by submerged pipes, retains its hardness under the most trying circumstances.

With the altered views amongst medical men as to the treatment of fever and many inflammatory diseases, ice becomes a positively essential therapeutic agent in warm latitudes.

Z*.—ON RENDERING SEA-WATER POTABLE.

The fact is generally appreciated, that Nature adopts two processes of water-purification for the requirements of mankind. The most universal is distillation or evaporation, and recondensation in the form of rain; and some towns, like New Orleans, are compelled to make use of rain-water, owing to the gross impurities of other sources of supply. In many cities, the rivers whence palatable water is obtained are polluted by sewage; and where wells have been common, the infiltration of soil by excreta, and other surface impurities, have been active agents in the propagation of filth diseases, such as typhoid fever and Asiatic cholera. Rain and distilled water are insipid and unpalatable. They are set aside for bright, sparkling, hard waters, which are often surcharged with organic germs; and throughout the South and Southwest many towns exist where a pure palatable water would be regarded as an unqualified boon, hitherto beyond reach.

The formation of ice, or crystallization of water, effectually removes all suspended or dissolved impurities calculated to engender disease. Ice-water is one of the necessaries of life in America, and if the ice were made so as to remove the discharged effete matter, its general employment would tend materially to reduce the prevalence of some of the maladies of towns. The natural ice supplied now always contains much dirt, which can be obtained in quantities from the bottoms of ice-jugs.

By means of a thermo-glacial engine, the cost of purifying, and rendering palatable, one hundred gallons of water, will not exceed fifty cents;

and this at once indicates the wide application of an entirely new system of supplying communities with pure water, where under existing circumstances none can be had.

Professor Baird, in the letter requesting me to furnish information at my disposal on the manufacture of ice and the preservation of fish, has directed my special attention to the dearth of water in places on the sea-coast, such as Gloucester, Mass. This opens up a wide field of operations wherever ice-machines are established for the use of fisheries; and without attempting to determine the extent and actual form of appliances required in practice, the data at our disposal indicate the feasibility of making ice from sea-water and supplying a town with drinking-water of great purity.

M. Tellier, having described the congealer in his 1869 patent, goes on to say that another application, hitherto vainly attempted, is the preparation of fresh water at sea by means of congelation. It is a well-known fact that the water of the sea, when congealed, casts off the salts which it holds in solution, and that water is thus obtained quite as fresh as that produced by distillation, with this difference, however, in favor of the congealing process, that while a glass of distilled water can hardly be swallowed, there is no pleasanter drink than melted ice. Let the congealer be filled with sea-water, allow sufficient time for congelation to take place, and then run out the liquor laden with salts; the fresh water, in the shape of ice, will remain in the apparatus. This ice, being allowed to melt, will furnish, either alone or mixed with distilled or other water, excellent drinking-water, fit for any purpose.

Messrs. Henri Merle & Co., at Giraud, on the Mediterranean coast of France, adopted M. Carré's ammonia-machines soon after they were first constructed, at their salines, covering 25,000 acres.* Four-fifths of the chloride of sodium is removed from the sea-water by solar heat. A mixture of sulphate of magnesia and chlorides of magnesium and potassium remains in the mother-water, and this, on being subjected to $-18°$ C., or a little below $0°$ Fahr., yields, by a double decomposition of common salt and sulphate of magnesia, sulphate of soda, which deposits in crystals, and a solution of magnesium chloride. The sulphate of magnesia is almost entirely withdrawn from the water, and the sulphate of soda which is obtained is a valuable commercial product, being the material from which carbonate of soda is prepared. The waters are now subjected to evaporation over the fire, and the remaining common salt which they contain is deposited in the form of the most beautiful fine salt. The chlorides of magnesium and potassium still remain in solution; but when the concentration has reached the specific gravity 1.31, the solution is allowed to flow over a broad surface of concrete (béton), where, in cooling, it parts with all the potash it contains in the form of a double chloride of potash and magnesium. The remaining water, containing only chloride of magnesium, is rejected. This waste salt may hereafter prove of great value as a cryogen, and I have used its watery solution exten-

*General Survey of the Paris Universal Exhibition, 1867. Washington, 1868.

sively, in the place of the aqueous solution of glycerine, as an uncongealable liquid in connection with ice-machines.

The double chloride of potash and magnesium, washed with half its weight of cold water, yields three-quarters of its potash in the form of chloride of potassium; and the remaining quarter, still held in solution in the water used in this final operation, is returned to the boiler. The commissioners of the United States who reported on this process in 1867 remarked that "the separation of potash from sea-water, thus effected, is one of the most important and valuable results which science has, in modern times, contributed to the industrial arts. Though potash is the most useful of the alkalies, the natural sources from which it is possible to obtain it economically are very few in number. Hitherto the supply has been chiefly derived from the ashes of land-plants, from which it is separated by lixiviation. This resource, which continually grows more precarious as civilization advances and as forests disappear, is destined, doubtless, to give way to the process just described, and which has already been for a number of years in active and successful operation."

Messrs. Merle have applied the treatment above described to mother-waters amounting to 100,000 cubic metres per annum, with an annual product of 4,000 tons of anhydrous sulphate of soda, 1,000 tons of chloride of potassium, and 12,000 tons of refined table-salt.

The waters leaving the refrigerators do not form incrustations in the boilers, owing to the almost complete decomposition of the sulphate of magnesia during refrigeration, the removal of sulphuric acid, in the sulphate of soda, and the increase in the quantity of magnesium chloride.

By a process of downward freezing, such as I have described, pure ice forms on the cooled metal surface and the salt-crystal deposit. Professor Guthrie has in this way obtained ice containing only 0.4052 of solid residue per cent. He experimented with sea-water from Dover, having, after filtration at 760^{mm}, the boiling-point of 100°.6 C., while the temperature of its vapor was 100°.2. This sea-water began to freeze at 2° C., for two hours the percentage of solid residue was 6.5786. A large beaker of this sea-water was cooled to 0° C. A tin vessel was supported inside the beaker, so that its bottom just touched the surface of the water, and a freezing-mixture was placed in the tin vessel. When about one one-hundredth of the whole had solidified, the solid was removed and divided into two parts: one was allowed to melt, and its percentage of solid matter was determined as above; the other was broken up and frequently pressed between linen and flannel in a screw-press, being allowed to melt as little as possible. The percentage of solid matter in this was also determined. The following numbers show the result of this examination:

	Per cent. at 100° of solid residue.
Sea-water	6.5786
Frozen sea-water	5.4209
Frozen and pressed sea-water	0.4925

"It appears, then," says Professor Guthrie, "that under these conditions the freezing of sea-water is little more than the freezing of ice, and that the almost undiminished saltness of the unpressed ice is due, as suggested by Dr. Rae, to the entanglement amidst the ice-crystals of a brine richer in solid constituents than the original water itself. Such brine, which is here squeezed out in the press, drains in nature down from the upper surface of the ice-floe by gravitation, and also is replaced by osmic action by new sea-water which again yields up fresh ice; so that while new floes are porous and salt, old ones are more compact and much fresher, as the traveller observed. . . . The degree of saltness of a floe depends not only upon its age, but also upon the rapidity with which it was at first formed, and upon the lowest temperature to which it has subsequently been exposed."

Mr. Guthrie justly supposed that the ice of the sea is mainly formed at or near the surface by radiation from the surface into space, and by contact with the colder air. He imitated this by hanging a blackened tin pan, containing a freezing-mixture, within one-eighth of an inch of the surface of the sea-water and thus obtained the ice which, on being pressed, contained a minimum solid residue.

CONCLUSION.

It had been my intention to enter into practical details concerning refrigerators, refrigerator-cars, and the methods of making pure ice economically. The time and space occupied preclude this now, but the opportunity for giving a connected history of the numerous efforts made of late years to extend the benefits of refrigeration for man's wants will not be neglected, if only in the fishing interests.

WASHINGTON, October, 1879.

ALPHABETICAL INDEX

NOTE.—A separate index to the report of the Commissioner will be found at its close, and another to the report on the Menhaden fishery, by G. Brown Goode, on page 519.